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BUILDING SUSTAINABILITY IN AN URBANIZING WORLD

A Partnership Report

THE WORLD BANK

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BUILDING SUSTAINABILITY IN AN URBANIZING WORLD

A Partnership Report

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Produced by the World Bank's Urban Development and Resilience Unit of the Sustainable Development Network, the **Urban Development Series** discusses the challenge of urbanization and what it will mean for developing countries in the decades ahead. The Series aims to explore and delve more substantively into the core issues framed by the World Bank's **2009 Urban Strategy Systems of Cities: Harnessing Urbanization for Growth and Poverty Alleviation**. Across the five domains of the Urban Strategy, the Series provides a focal point for publications that seek to foster a better understanding of (i) the core elements of the city system, (ii) pro-poor policies, (iii) city economies, (iv) urban land and housing markets, (v) sustainable urban environment, and other urban issues germane to the urban development agenda for sustainable cities and communities.

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Abbreviations and Acronyms

C40	Cities Climate Leadership Group
CBD	United Nations Convention on Biological Diversity
CDM	Clean Development Mechanism
CNG	Compressed natural gas
CUD	Connected Urban Development program
EO	Earth observation
GCI	Great Cities Institute
GDP	Gross domestic product
GER	Gross energy requirement
GIS	Geographic information systems
IBSG	Internet Business Solutions Group
ICLEI	International Council for Local Environmental Initiatives
ICT	Information and communications technology
IFI	international financial institution
IPCC	Intergovernmental Panel on Climate Change
IRP	integrated resource planning
ISO	International Organization for Standardization
LCA	Life-cycle assessment
MDB	Multilateral development bank
MSW	Municipal solid waste
OECD	Organisation for Economic Co-operation and Development
PER	Process energy requirement
PES	Payments for ecosystem services
RFSC	Reference Framework for Sustainable Cities
SSD	Smarter Sustainable Dubuque
TDR	Transferable Development Rights
UCLG	United Cities and Local Governments
UEA	Urban Environmental Accords
UN	United Nations
UNEP	United Nations Environmental Programme
USC	Urban Systems Collaborative
USGBC	U.S. Green Building Council
WBCSD	World Business Council for Sustainable Development
WFEO	World Federation of Engineering Organizations

All dollar amounts are U.S. dollars unless otherwise indicated.

FOREWORD

Photo: Curt Carnemark/World Bank

About 3.7 billion people now live in urban areas, and that number is expected to double in just 50 years. With urbanization, more people have access to basic services, literacy, good jobs, and longer lives. But urbanization also raises concerns about whether cities can finance enormous amounts of infrastructure for millions of new citizens, adequately plan for land requirements, provide basic services—and do all of this in a way that strengthens social capital, preserves the integrity of the Earth's ecosystems, and prepares for the shocks of climate change.

We need to assemble what facts we can, and anticipate how best to proceed in the face of uncertainty. And we need to build new partnerships and strengthen existing ones to embark on the challenging journey ahead.

While cities face urgent challenges, from urbanization and climate change to increasing global competitiveness, inequity, and resource constraints, the opportunity for technology to help address these challenges has also never been greater. Information and communications technology (ICT) may be able to drive efficiency gains through better monitoring of infrastructure and more responsive services. The Climate Group's Smart 2020 report (2008) estimated that, globally, ICT-enabled solutions for smart grids, smart buildings, and smart logistics and industrial processes can reduce greenhouse gas emissions by as much as 7.8 Gt in 2020—a reduction larger than total emissions produced by China in 2010. In addition, technology is driving integration across traditional city department silos. Smart grids are bringing together our energy and telecommunication systems, and electric vehicles are connecting our transport systems with our energy networks.

Smart cities are just one of the paradigm shifts that will be needed to build sustainability in an urbanizing world. This paper, the first product of the Partnership for Sustainable Cities, presents a wide range of approaches for the different aspects of urban sustainability. The focus is on how to operationalize this knowledge, especially for developing-country cities.

The world's headlong rush to urbanize is now half complete. The next 10 years are critical; as managers and leaders build up fast-growing cities, they are locking in humanity's and the planet's future. Seemingly small things can have major impacts. This report is one such small step for an influential and concerned group of partners. The work is intended to help cities—the real drivers of change.

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This report was prepared by a team led by Daniel Hoornweg, Mila Freire, Julianne Baker Gallegos and Artessa Saldivar-Sali under the overall direction of Abha Joshi-Ghani and Sameh Wahba, Managers of the Urban Development and Resilience Unit, and Zoubida Allaoua, Director of the Urban and Disaster Risk Management Department. The main authors and contributors for each chapter are listed below. This report was developed following a'wiki-like' approach in an effort to compile multiple issues and sectors relevant to sustainable urban development. It is a product of the contributions of over 40 authors, and is presented as input for further dialogue across sectors and to help frame the discussion on urban sustainability. The report itself exemplifies the Partnership for Sustainable Cities effort to foster improved collaboration on city-led sustainable development.

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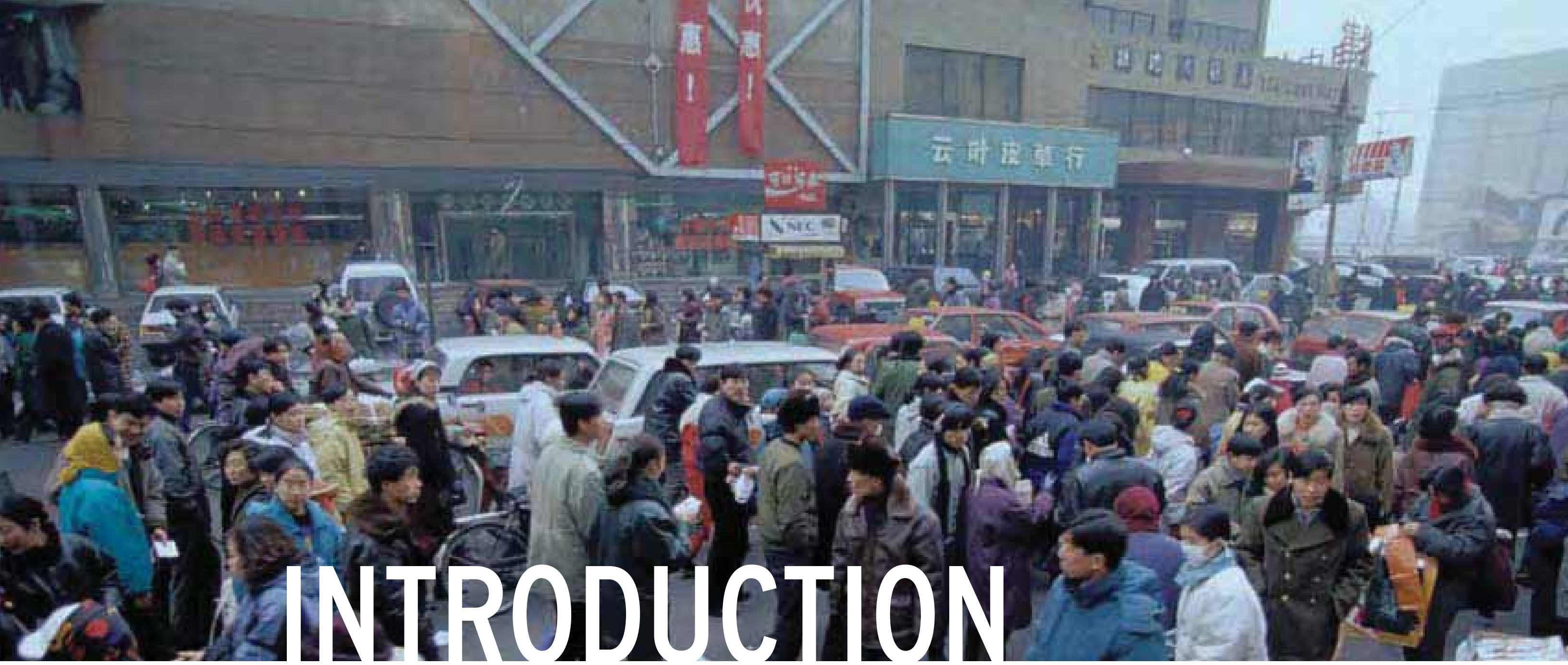


INTRODUCTION

Photo: Curt Carnemark/World Bank

Cities are hubs of global change, and their global influence continues to grow. Cities contribute significantly to global challenges like climate change and biodiversity loss. At the same time, cities experience impacts like climate change first and with greatest intensity. Further, cities are becoming leaders worldwide in efforts to address global environmental and social problems.

Some of the most important smaller-scale agreements and partnerships emerging from Rio+20 (the United Nations Conference on Sustainable Development) were initiated by or focused on cities. Even as the conference reinforced the increasing difficulty of reaching consensus on global challenges, it also saw smaller-scale agreements and partnerships emerge. Some of the most important "microagreements" focused on cities. For example the host city of Rio de Janeiro unveiled its own low-carbon growth strategy.

The impacts of city-level agreements will not necessarily be smaller than those of national accords. Many of the concrete steps toward sustainable development can and must be enacted by municipal governments— for example efficient and adaptive building standards, public transportation, "smart" power grids or flood protections. The Rio summit itself identified sustainable cities as one of seven critical issues in coming decades. And the other six—adequate jobs, energy, food security and sustainable agriculture, water, oceans, and disaster readiness and resilience—demand solutions that will be conceived, piloted, and mainstreamed mainly in cities.

Developments in Rio showcased the pragmatism and enthusiasm associated with sustainable cities. Reviewing progress since the first UN Conference on Environment and Development 20 years before, Rio+20 found some remarkable improvements, notably in recognition of the role played by local governments, their willingness to cooperate and eagerness to share information, and the emerging synergy between research, business and the public sector. The initiatives announced at Rio followed several regional partnerships on cities and climate change in places such as Germany, Australia and Mexico (Newman and Jennings 2008).

Cities are increasingly recognized as a priority for inclusive green growth, particularly in rapidly growing cities where it is essential to avoid locking in inefficient urban forms. Moving forward, further solidifying relationships among partners and local governments is critical. The issue of cities and climate change has been explored by academics, policy makers and private sector entities (Hoornweg, Freire, et al. 2011). There is now ample evidence to confirm the impacts of urban spatial forms, operations and governance on greenhouse emissions and to demonstrate effective strategies for climate change mitigation and adaptation. Substantial work toward quantifying how cities "metabolize" resources and obtain clear indicators that facilitate strategies to compare and monitor policy effectiveness is available. Private sector partners want to harness the extraordinary opportunities for innovation and business development in cities, while both public and private partners are closely engaged with city administrations. Existing experiences, toolkits and technologies that have been tested in cities around the world are ever more in demand. Dialogue among cities and the kinds of partnerships that are developing from Rio+20 have never been more relevant than they are today.

Among the urban partners emerging in recent years, the foremost are cities themselves and their national representatives; agencies and networks such as C40, ICLEI Local Governments for Sustainability, United Cities and Local Governments (UCLG) and Metropolis; the Climate and Clean Air Coalition, a group of national government representatives; multilateral development banks such as the Inter-American Development Bank, Asian Development Bank, and the World Bank; UN-Habitat; the United Nations Environmental Programme; the World Federation of Engineering Organizations; private-sector companies; the academic community; philanthropic organizations like the Rockefeller Foundation and the Clinton Climate Initiative; and technical agencies like the Green Building Council and the Climate Development Program.

To support this movement, the World Bank initiated the Partnership for Sustainable Cities, a group of leading urban actors with a mission to collaborate on city development around the world and foster city-led sustainable development. This synthesis paper is a product of the partnership's early discussions.

About the Partnership

The Partnership for Sustainable Cities aims to bring together actors in the private sector, academia, and international financial institutions (IFIs), and to help coordinate their efforts to build inclusive, sustainable and resilient cities. The Bank and other partners are well positioned to provide technical and financial backing for these efforts.

The idea of such a partnership started as early as 2009 and was cemented during a seminar in Washington, DC, in June 2011. Attended by 70 representatives of private companies, international organizations, academic institutions and the World Bank, the workshop invited participants to share their ongoing programs related to sustainable cities, to consider establishing a partnership for exchanging information, and to discuss the need for common tools and case studies. Three key questions were proposed: What do we need to know? How do we take into account the varied characteristics of cities in developing countries? And what is the role of indicators in the context of city sustainability?

The June 2011 meeting and follow-on discussions were rich in ideas and consensus, as participants came to agree on an agenda for collaboration. The participants saw clear benefits from a partnership of local governments and institutions interested in sustainable cities, and anticipated sharing information, experiences and lessons learned.

Individual partners committed to pursue several specific initiatives, including a compendium of data on the world's 100 largest cities (Chapter 5), a sustainability rating tool for infrastructure, and other projects (Chapter 8). More generally, the group agreed to learn more about existing solutions, examine the role of the private sector, explore opportunities to cooperate, define common approaches, and monitor progress toward the goals set at the meeting.

About This Report

In this discussion paper, members of the partnership have collaborated to identify and analyze the issues that guide their work together. The report summarizes the sustainability issues faced by cities and points toward the road ahead. It reviews successes in policy as well as investment, and discusses what is needed to reach out to the rapidly growing cities of the developing world and make them effective users of existing knowledge. Examples of programs established by the partners are described in both the text and the Annexes.

Compiled from the contributions of over 40 authors, this document should not be considered a comprehensive synthesis, but rather a work in progress. It is an input for dialogue across sectors and for framing a loose partnership platform. The report and its writing process also exemplify the partnership's efforts to coordinate multiple stakeholders and help them create more sustainable cities through a series of constantly evolving actions. By working together in the development of this paper, the partners established a common understanding of the key elements of a strategy for urban sustainability. This supports the partnership's central mission: fostering worldwide collaboration on city-led sustainable development.

This report aims to be useful to the partners who contributed with knowledge and experiences, to cities who may benefit from an honest discussion of what works and what needs improvement, and to businesses and development practitioners entering the wide world of sustainable cities.

The report is organized into eight chapters:

Chapter 1 discusses urbanization and the growing global impact of cities, reviews the widely accepted definitions of sustainability and sustainable cities, and elaborates on the need for innovative approaches to the various aspects of sustainability.

Chapter 2 reviews the importance of urbanization for economic growth and the opportunity for low-carbon investments to promote growth and job creation in developing countries.

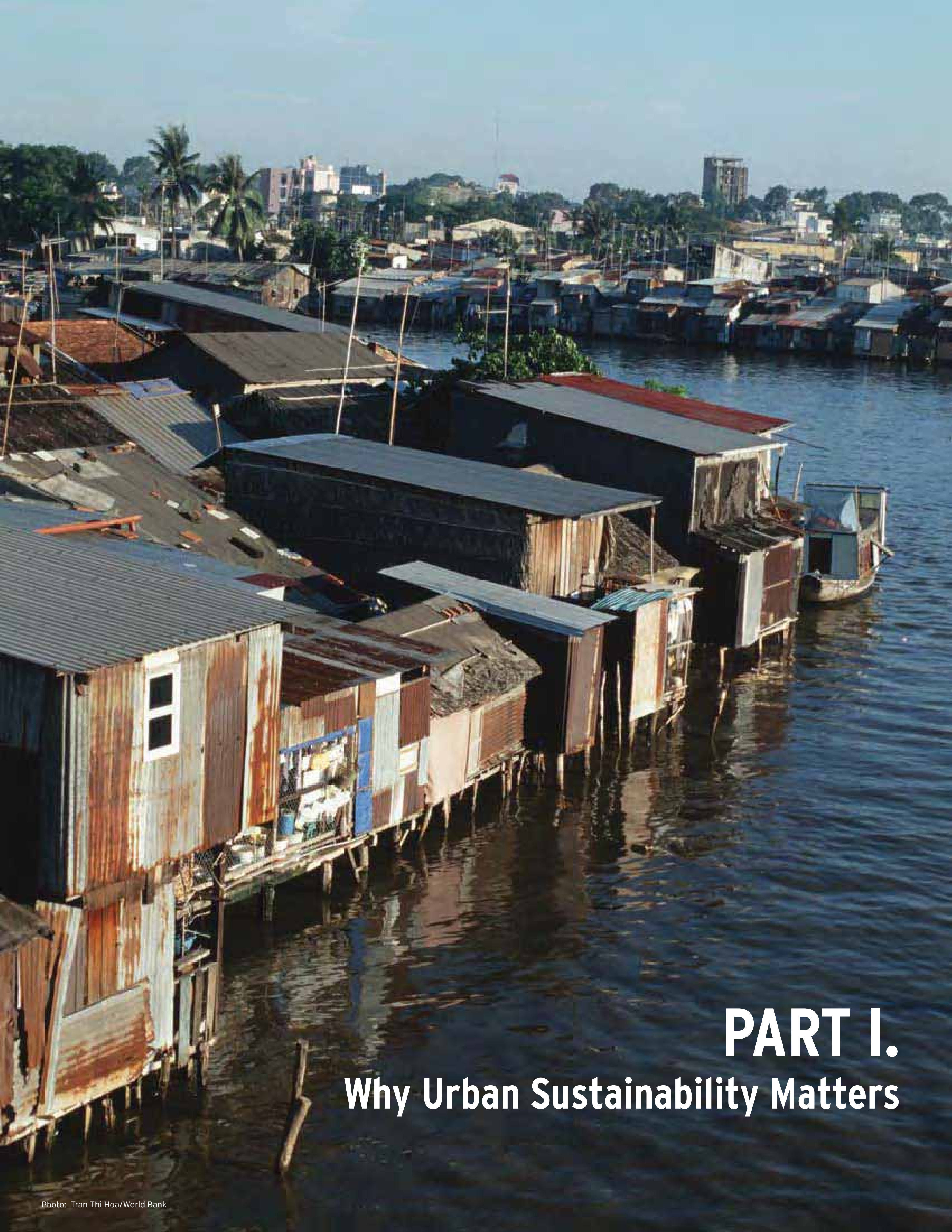
Chapter 3 discusses the ways in which policies dealing with land and urban form can promote greener growth, as well as how cities can take advantage of the enormous demand for infrastructure to become cleaner and more efficient. It summarizes issues related to energy efficiency, buildings, urban transport, water, and waste.

Chapter 4 discusses climate change adaptation in cities. Approaches for local adaptation planning, risk management and resilience are reviewed.

Chapter 5 debates how to measure improvements in urban sustainability. It reviews the framework of urban metabolism for understanding the flow of materials and energy, and explores the use of indicators to measure aspects of sustainability—including risks and resilience as well as efficiency. A new compendium of data from the world's 100 largest urban areas is introduced, and a basic typology of these cities is presented.

Chapter 6 discusses the roles of different institutions in the governance and implementation of sustainable cities, and Chapter 7 considers how institutions can contribute to learning and innovation.

Chapter 8 suggests next steps to move toward sustainable cities, identifying possible paths forward with partners.



PART I.
Why Urban Sustainability Matters

Photo: Tran Thi Hoa/World Bank

1 Sustainable Development in the Urban Century

Key Messages

- **Sustainable cities are critical to sustainable development, given their position as engines of economic growth, centers of population growth and resource consumption, and crucibles of culture and innovation.**
- **Cities must adopt sustainable development policies as soon as possible because today's infrastructure investments will be locked in for hundreds of years. This is all the more urgent in developing countries that are rapidly urbanizing.**
- **Sustainable cities should be defined broadly, integrating environmental, economic, and social objectives, and should be supported with a comprehensive and customizable how-to menu.**
- **Making cities sustainable requires addressing knowledge gaps, broadening participation across stakeholders, and incentivizing behavioral change at the individual, corporate, and local government levels.**

As the environmentalist Lester Brown warned decades ago, a pond that will be covered by the exponential growth of water lilies in 30 days is only half covered on the 29th day (Brown 1978). So we stand today with urbanization. Almost all the growth that cities have experienced in the last 200 years is about to double in the next 40 to 50 years (see Box 1 and Annex 1). Much of this growth will take place in low- and middle-income cities, where 80 percent of the world's urban population is expected to reside in 2020. Africa, Asia, and Latin America will be home to a majority of the world's urban population, while Europe, North America, and Oceania's shares are projected to decline steadily until 2050 (Figure 1).

Since the first humans began living in groups that stayed in place while they tended crops and livestock, ours has been a history of urbanization. Today's big problems—climate change, financial shocks, biodiversity loss, soil degradation, civil unrest, potential pandemics, wars, and strife over resources—are in part the by-products of this urbanization. So, too, are many of humanity's greatest accomplishments—increased affluence, better health and well-being, longer life expectancy, culture and the arts, technological and creative innovation, and reducing the number of people living in extreme poverty from 1,818 million in 1990 to 1,374 million in 2005.[1]

Cities as permanent places of residence are as old as civilization itself. Damascus, for example, is believed to have been continuously inhabited since 9,000 B.C. Contrast this to companies, and even countries, which come and go. The average life expectancy of a Fortune 500 company is a mere 40 to 50 years.[2] Of today's 194 sovereign states, only nine have existed freely and continuously since before 1800. The size and economic might of a city may ebb and flow, but its connection to the land and integration with natural ecosystems is relatively permanent. Cities are the physical places

[1]PovcalNet, http://iresearch.worldbank.org/PovcalNet/povcalNet.html
[2]http://www.businessweek.com/chapter/degeus.htm

Drivers of Urbanization

BOX 1

The sheer magnitude of population and investments in urban areas, combined with the suite of services required to support them, make cities intricate, complex systems with equally complex problems. In order to address these problems, it is important to understand the drivers of urbanization and how these affect the vulnerability of the city system to global change.

In simple terms, urbanization is the result of a movement of people from rural areas to urban areas (Sattherthwaite et al. 2009), both within their own countries and trans-nationally. The underlying cause is attraction to economic, cultural, social, and educational opportunities, along with the quality of life that a city provides.

Rapidly urbanizing nations have a history of economic expansion and a shift in employment patterns from rural, agricultural, or pastoral activities to industrial, service-oriented, or knowledge-based activities. As a result of such trends, by 2004, 97 percent of the world's gross domestic product (GDP) was generated by industry and services (Sattherthwaite et al. 2009). Thus, people evidently are moving toward the job opportunities offered in cities for a higher quality of life, which involves a higher salary and less physically labor-intensive jobs.

Yet this is a simplistic generalization, as some of the world's largest cities (for example, Buenos Aires, Kolkata, Mexico City, Rio de Janeiro, São Paulo, and Seoul) have had more people leaving than moving to the city during their most recent census periods. Counterexamples like these illustrate the importance of location- and time-specific studies and data gathering to inform policy making at the national level. It is also important to recognize that cities are dynamic systems—growing, prospering, or declining according to macroeconomic policies, international trade regimes, shifting national and international migration patterns, and impacts from disasters such as earthquakes, droughts, or wars (Sattherthwaite et al. 2009).

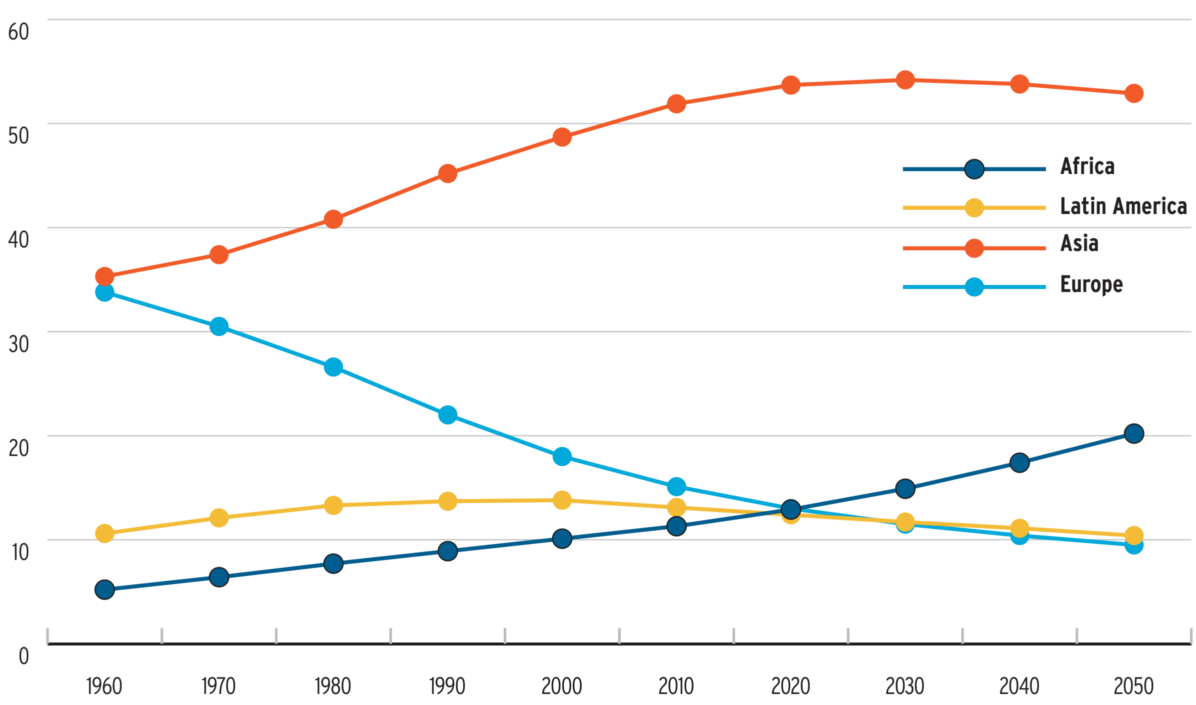


FIG. 1
Shares of World Urban Population and Regional Totals (2010–2050)

Source: Hoornweg and Bhada-Tata in press.

where we live, or want to; countries and companies are what we create largely to protect and serve our cities.

The only path to sustainable development is through sustainable cities (see Box 2). Yet most of the world's media and political leadership focus on national and international geopolitical issues: the economic crises in Europe, climate change, the Arab Spring, the "war on terror," China's ascendancy. We are very good at discussing global symptoms. Arguably, over the last several decades, while the world attended to economic growth and geopolitical dynamics, the exponential growth of cities (Figure 2) went largely unnoticed.

Only in the last 10 to 15 years have cities and urbanization entered the common political and policy discourse. This will be an urban century, and the potential for poorly designed and rapidly growing cities is a crucial challenge to sustainable development. While some see the speed of urbanization as a threat to the carrying capacity of our planet, others emphasize the need "to envision human settlements in more positive ways, first to reduce per capita impacts but then to move to a new and more exciting possibility where cities begin to be a positive force for the ecological regeneration of their regions" (Newman and Jennings 2008). The discussion on urbanization, and the potential threats and opportunities it presents, is starting in earnest.

BOX 2

Key Concepts for Urban Sustainability

- ***Green growth*** refers to making growth processes more resource efficient, cleaner, and more resilient, without necessarily slowing them (Hallegate et al. 2011). The focus is on what must happen over the next 5–10 years, before the world gets locked into patterns that would be prohibitively expensive and complex to modify. The short and the long term can be reconciled by offsetting short-term costs and maximizing synergies and economic co-benefits, green growth "shifts the production frontier by promoting innovation and harnessing potential synergies across sectors" (Hallegate et al. 2011). Green policies that can be used to capture these co-benefits include price-based policies, norms and regulation, public production and direct investment, information dissemination, education and moral suasion, industrial policies, and innovation policies.
- ***Green cities*** are seriously committed to becoming environmentally responsible. Many have undertaken internal environmental audits to understand the impact of their policies, and many have become certified under the European Union's Econ-Management and Audit Scheme. Cities such as Den Haag and London have calculated their ecological footprints and are using these measures as policy benchmarks (Beatley 2007).
- ***Smart cities*** have adopted technical and information platforms to better manage the use of their resources, improve management, monitor developments, develop new business models, and help citizens to make informed decisions about the use of resources.
- ***Resilient cities*** have the ability to respond to natural disasters and system shocks, and can provide reliable services under a wide set of unpredictable circumstances. These are cities that have built-in systems, such as diverse transport and land use, that can adapt to change (Newman 2009).

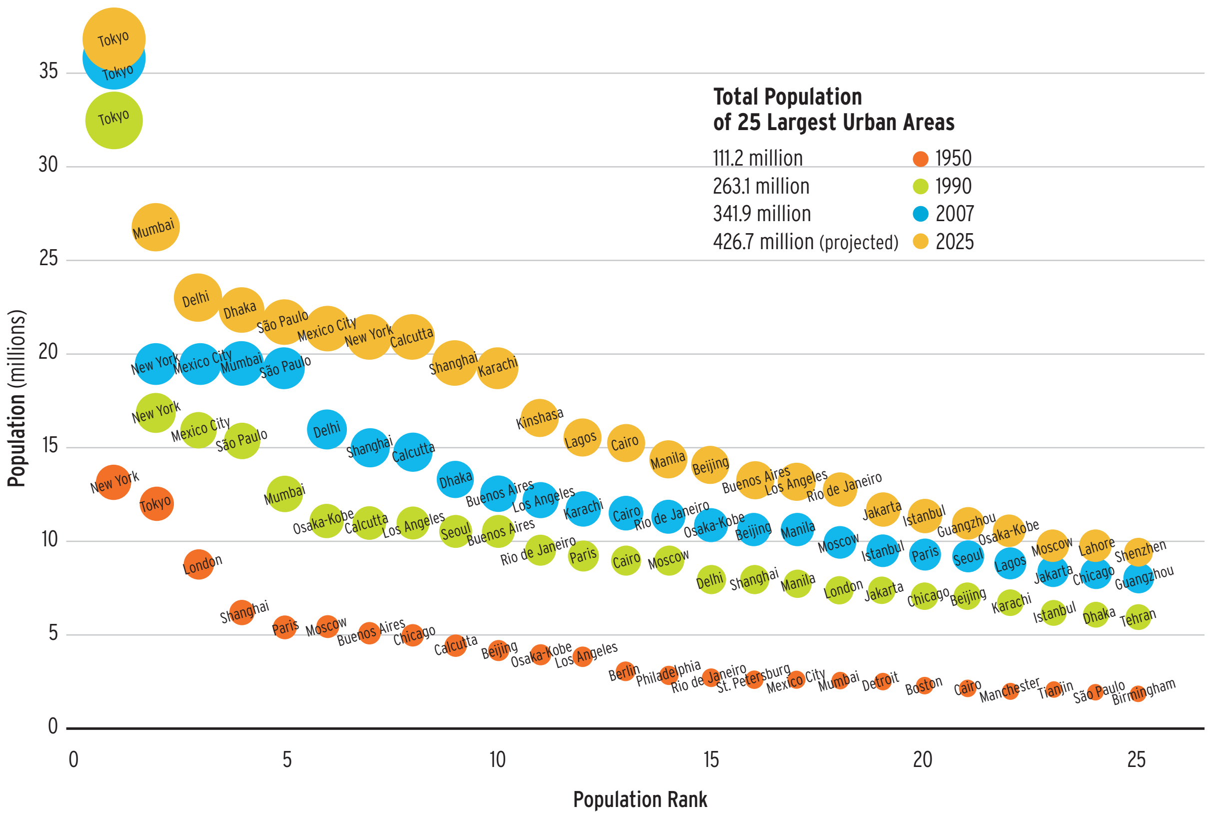


FIG. 2
Population Growth in the 25 Largest Urban Areas

Source: developed by authors with data obtained from UN (2012).

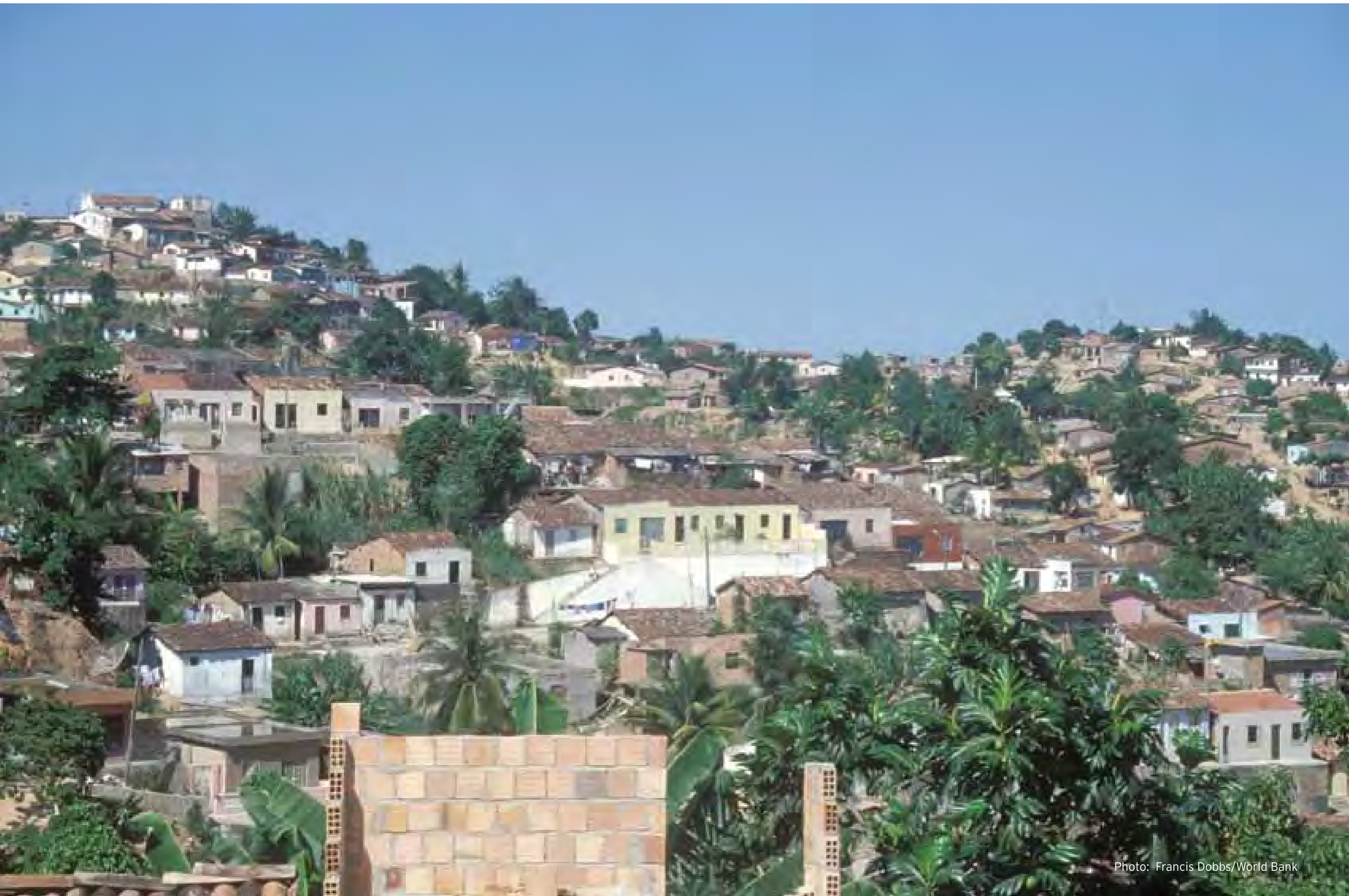


Photo: Francis Dobbs/World Bank

Local Impacts, Global Change

As the world has become more urbanized, the importance of urbanization and density for growth and prosperity has become widely accepted. Currently, urbanized areas host more than half the of world's 6.7 billion people and account for 70 percent of the world's GDP. They are seen as engines of growth, contributing to poverty reduction, improved living conditions, cultural development, and knowledge generation.

Yet cities also affect the lion's share of global and local environmental problems. Cities account for approximately 70 percent of energy-related carbon emissions worldwide, and this is expected to increase to 76 percent by 2030, with most of the increase coming from rapidly urbanizing countries such as China and India. By 2050, urban dwellers are expected to exceed 70 percent of the global population. Hence, cities will continue to become more important as consumers of non-renewable resources (see Box 3) and as contributors to greenhouse gas emissions.

Consequently, global agreements that seek to tackle threats such as climate change, ozone depletion, or hazardous waste must integrate cities as key players. Cities generally delegate and empower their national governments to negotiate and exert influence on their behalf, but the resulting agreements by and large fall on cities to implement.

In the field of green development, a number of multilateral institutions such as the World Bank, the Organisation for Economic Co-operation and Development (OECD), and the United Nations Environmental Programme (UNEP), as well as private sector actors such as McKinsey, Siemens, IBM, and Cisco, have begun focusing on the design and efficiency of cities. Economic development

BOX 3

Finding the Energy for Growing Economies

Most cities in the northern hemisphere recognize that energy costs will increase as the demand for energy rises in the rapidly growing economies of the global South. Developed country cities will likely adapt to this new scenario by reducing energy use, and/or innovating to make available new, sustainable energy resources. Regulatory frameworks or new policies are intended to provide the right incentives for structural change, focusing on knowledge generation and service provision rather than industrial production. Mixed-use neighbourhoods and interconnected systems/grids to handle communications, energy, waste and transport will also be encouraged. Ultimately we would expect a transition from systems that depend on the linear use of resources, to highly interconnected systems that encourage the circular use of scarce resources.

This transition will require technical and social innovation. Grids of communication, energy, water, transport and monitoring sensors (components of the stereotypical smart city) will create intelligent, self-healing properties resulting in improved transport logistics with less congestion, high-efficiency resource flows, and reduced costs and environmental impact. Eco-innovation will help cities of the developed world to be sustainable, while creating the conditions for substantial improvement in the urban well-being.

The cities of the global south face a far more complicated challenge. They too must find sustainable energy—and more of it—as rapidly growing, young and increasingly affluent populations demand more energy to support industry and the consumer lifestyle. However, these cities are growing exponentially, unlike the stable cities of the global north. Informal settlers who are unable to find housing in the main city settle beyond organized boundaries, often in marginal and under-serviced areas without access to energy, clean water, transport, education, and health and sanitation services.

requires the capacity to welcome a growing number of urban inhabitants without increasing disaster risks and environmental degradation. In economic terms, sustainable cities attempt to maximize and share the large economic benefits from increased population concentration (Ciccone 2002; Ciccone and Hall 1996; World Bank 2009), while trying to avoid its negative externalities (for example, congestion, loss of resources, pollution, and natural disaster risks). City design will be central to our ability to rise to society's greatest challenges, namely encouraging growth, reducing poverty, and increasing living standards while minimizing the consumption of scarce resources.

Fortunately, cities can be efficient vehicles for sustainability, as leaders are close to their citizens and are able to directly implement much-needed policy changes on the ground. Key segments of the green economy agenda such as buildings, city form, energy, solid waste, and urban transport are usually under the responsibility of the local or regional authority.

Innovation and efficiency may also come more naturally in cities. Their high population density and compactness can allow for economies of scale and collaboration. They combine a mix of specialization and diversity derived from a concentration of people and economic activity that generate a fertile environment for competition and innovation in ideas, technologies, and processes.[3] They produce and distribute the resources that provide better livelihoods for urban and rural residents alike. Indeed, there is already evidence that resource-efficient innovations are being scaled up in cities, both in developed and developing countries. This is because cities connect a wide range of agents and assets, including workers, infrastructure, consumers, technologies, resource flows, suppliers, cultures, and histories.

On the other hand, their size and economic complexity mean that city-specific problems such as congestion, waste, pollution, education, and crime require considered public intervention. Indeed, cities are constrained by many of the same forces as sovereign states; the growing complexity of global systems is taxing current political structures at all levels.

However, cities are also able to act more independently and often are able to focus nascent leadership and the concerns of local residents. Efforts to reduce smoking and trans-fats in food can be catalyzed by vanguard cities. Saving the bluefin tuna will probably require a city to step forward and ban their sale. New social norms such as gay marriage are often initiated by and in cities. This potential for cities to lead wider change is often obvious only in retrospect. In the Agenda 21 agreement from the 1992 Rio Earth Summit, the chapter on local government was the shortest, but led to more action in the last 20 years than any other chapter.

Locking In Green Growth

The need for urban leadership is all the more urgent because choices made today will be multiplied over the next century or more. Approximately 2.3 billion people will move into cities within just the next four decades (United Nations 2011), and those people will need new infrastructure (see Box 4 and Table 1). The demand for housing and office space will continue to exceed supply, leading to more informality and slum dwellings, in the absence of vigorous policies to expand the supply of affordable solutions. China will double its housing stock between 2000 and 2015, and has already built some 40,000 highway miles in just the last 10 years. India is rapidly matching this growth. Energy consumption in developing countries will also increase sharply (IEA and OECD 2010).

[3]Take, for example, specialized restaurants. A large town can cater for specialized tastes and employ specialized chefs and specialized suppliers, inviting competition and attracting innovation and immigration by discerning clientele. By contrast, a small town will not have met the threshold demand size to make a specialist restaurant profitable, and most eating establishments will cater to a range of tastes by employing generalist chefs, who use a single supplier and appeal to the lowest common denominator.

TABLE 1
Infrastructure Levels of Countries, by Income

Average Values	Low-Income Countries	Middle-Income Countries	High-Income Countries
Urban population in 2009 (% of total population)	29	48	77
Per capita GDP ($)	1,200	8,000	38,000
Estimated greenhouse gas emissions per capita (tonnes/year)	1	4	23
Estimated municipal solid waste generation (kg/capita/day)	0.4	1.1	1.6
Energy consumption (kWh)	0.9	3	8
Percent of population in vulnerable housing	55	23	3
Road density (km per 1,000 people)	2.0	3.3	14.8
Paved roads (% of total roads)	12	38	87
Tele-density, 2008 (fixed lines + mobile cellular subscriptions/100 people)	33	72	155
Access to electricity (% of population)	30	73	100
Finance indicators ($ per capita)			
Gross capital formation ($ per capita)	137	1,086	8,374

Sources: World Bank Data Indicators[4]; World Bank 2012c; Hoornweg and Bhada-Tata 2012.

[4]http://data.worldbank.org/indicator

BOX 4

Can Infrastructure Keep Up with Demand?

The rising demand for urban infrastructure—housing, water, transport and energy—is a massive challenge for developing countries, both from an environmental and financial point of view. It is estimated that yearly investments of $1–1.5 trillion would be needed for developing countries to satisfy basic needs and provide infrastructure for sustained growth (EIB 2010). Currently, infrastructure investments (public or private) represent perhaps half that amount. Financing for maintenance and efficient management has often proven elusive, and attempts to attract private investors have had limited success, except in a few countries.

Photo: Julianne Baker Gallegos/World Bank

Photo: Shutterstock

Emerging economies that have to build the bulk of their infrastructure in the next two or three decades will be committing to either high- or low-resource-intensity development paths. Urban infrastructure such as buildings, transport systems, or water systems generally has a lifetime of at least 100 years. In addition, the location of infrastructure and building sites shapes the footprint of the city and its populations beyond the structure's lifetime (Gusdorf, Hallegatte, and Lahellec 2008; Gusdorf and Hallegatte 2007). And urban policies are multiplied not only over time, but socially. Most policy decisions affect social networks in which individuals' decisions on where to live, where to work, and how to commute have powerful effects on others, entrenching attitudes toward, for example, bicycling or living near the city center.

Thus, fast-expanding cities in the developing world present a window of opportunity. The choices that are made in the next few decades will determine the structure that prevails in these cities for centuries. High-intensity development paths require less careful planning and are likely to be cheaper in the short run, but extremely costly in the medium to long term. The high inertia of city structures calls for long-term planning based on long-term outcomes—often politically difficult, but essential for sustainability. Although changing course later on is a possibility, the costs of such reversal would be enormous.

While more data and studies are required to understand the effectiveness of alternative approaches, cities and their administrations cannot afford to wait for perfect information before making these sensitive decisions. Getting it right the first time can, in fact, accelerate urban economic growth in developing countries. Unfortunately, sustainable choices can be very difficult to fund, given the scarcity of resources and unmet demands for basic services.

Defining Sustainable Cities

How do we know if a city is on track for "sustainable development"? That term was first defined in the report *Our Common Future* (World Commission on Environment and Development 1987), also known as the Brundtland Commission report. The report's widely used definition is: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

BOX 5

Engineer's Definition of a Sustainable System

To an engineer, a sustainable system is "one that is either in equilibrium, or one that changes slowly at a tolerable rate." This concept of sustainability is best illustrated by natural ecosystems, which consist of nearly closed loops that change slowly. For example, in the food cycle of plants and animals, plants grow in the presence of sunlight, moisture and nutrients and are then consumed by insects and herbivores that, in turn, are eaten by successively larger animals. The resulting natural waste products replenish nutrients, which allow plants to grow and the cycle to begin again. If humans are to achieve sustainable development, we will have to adopt patterns that reflect these natural processes. The model of a closed-loop ecosystem was first proposed by the World Federation of Engineering Organizations in a 1990 publication, and other authors have since suggested modifications to this model.

Source: Reprinted from WFEO ComTech (2002).

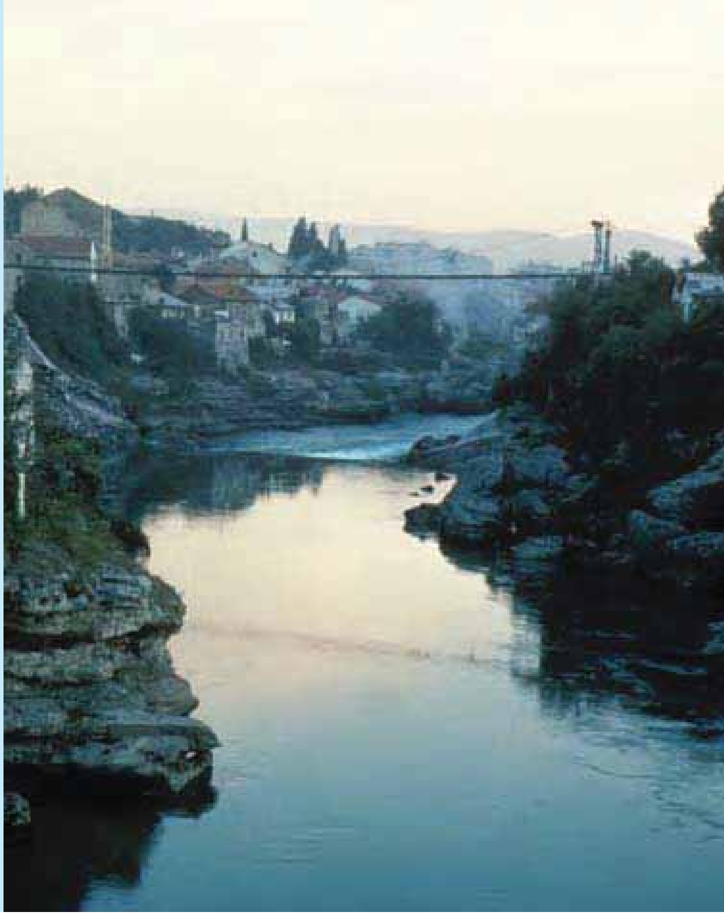


Photo: Michael Mertaugh/World Bank

Since 1987 there have been many efforts to explain and elaborate on what sustainable development means, and at present at least two definitions are regularly used. One emphasizes an engineering-oriented formulation that considers material flows and the impact that human consumption and production have on the local and global environment (see Box 5). A second definition suggests that sustainability must include a wider set of characteristics, including social and equity issues, institutional capacity and participation, and fiscal sustainability. In this second definition, sustainability is often described as having three interdependent pillars: economic, environmental, and social. For example, the World Bank's Urban and Resilience Management Unit currently defines sustainable cities as "urban communities committed to improving the well-being of their current and future residents, while integrating economic, environmental, and social considerations."

The connections between the three pillars are especially evident in cities, which function as integrated systems. In some cities, environmental degradation is already an obstacle to well-being and poverty reduction. Uncontrolled urban development may lead to a reduction in soil permeability and drainage capacity that increases flood risks and the economic costs associated with them, such as lack of economic competitiveness and poor well-being. It also disproportionately hurts the urban poor, especially those living in informal settlements, reducing their ability to accumulate capital and escape poverty (Lall and Deichmann 2011). The reverse is also true; poverty may be a cause of increased flood risks when lack of resources leads poor people to settle in marginal areas with limited access to basic services, where drainage infrastructure cannot be extended and solid waste disposal is inadequate.

One useful set of markers for urban sustainability is the so-called Melbourne Principles, articulated at a 2002 meeting, which attempt to include the ecosystem dimension as well as the social and institutional characteristics that affect city performance (Table 2). In preparing this report, members of the Partnership for Sustainable Cities worked to

TABLE 2
The Melbourne Principles of Urban Sustainability

Principle	Definition
1. Vision	Provide a long-term vision for cities, based on sustainability (intergenerational, social, economic), political equity, and their individuality.
2. Economy and society	Achieve long-term economic and social security, move toward urban eco-villages embedded into the bioregional economies, encourage urban agriculture, adopt true costing initiatives, buy local.
3. Biodiversity	Recognize the value of biodiversity and natural ecosystems, protect and restore them.
4. Ecological footprints	Enable communities to minimize their ecological footprints.
5. Modeling cities on ecosystems	Build on the characteristics of ecosystems in the development and nurturing of healthy and sustainable cities.
6. Sense of place	Recognize and build on the distinctive characteristics of cities, including their human value and natural systems.
7. Empowerment	Empower people and foster participation.
8. Partnerships	Promote and enable cooperative networks towards a common sustainable future.
9. Sustainable production and consumption	Promote sustainable production and consumption through sound technologies and effective demand management.
10. Governance and hope	Enable continuous improvement based on accountability, transparency, and good governance.

Sources: UNEP 2002; Newman and Jennings 2008.

develop their own shared sense of what defines a sustainable city and what are its critical building blocks. Participants in a "Defining Sustainable Cities" workshop in 2012 favored a wide concept of sustainability, going beyond environmental impacts alone. However, defining urban sustainability is a complex task. Any given city's sustainability is influenced by its historical and cultural context, its goals (livability or business development, for example), and its local geography and environmental conditions. Moreover, partners from different sectors preferred different definitions of sustainability at the city level.

Rather than a one-size-fits-all definition, one can use a "word cloud" to represent the partnership's views (Figure 3). The figure lists key characteristics for urban sustainability, as defined by the workshop participants. In addition, Chapter 5 reviews in detail various ways that city sustainability can be measured.

Also discussed at the workshop was the need for a comprehensive and customizable how-to program for sustainable cities. Participants argued that there is a hierarchy among the actions to be taken, as cities need to focus first on basic service provision before tackling other levels of design and governance. Figure 4 expresses this idea in a draft model.

FIG. 3
Characteristics of a Sustainable City

Source: World Bank

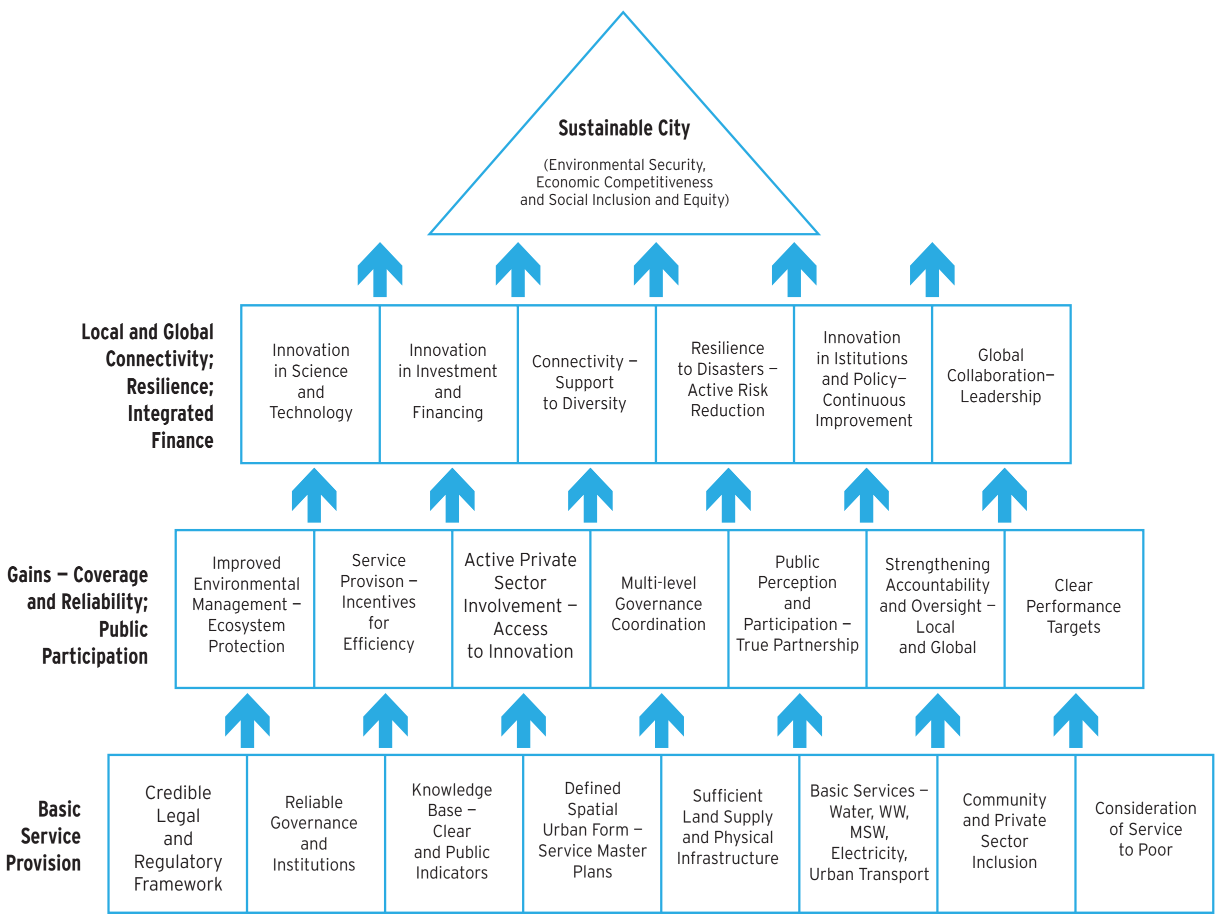
NOTE: Size of text corresponds to frequency of each word in definitions of sustainable cities suggested by participants at the World Bank workshop "Defining Sustainable Cities," Washington, DC, (January, 2012).

The hierarchy framework draws from the three pillars of sustainable development: economic competitiveness, environmental sustainability, and social equity. The base of the pyramid represents the foundation of basic services that all cities require. The specifics are unique for any given city, but in general the foundational building blocks shown here create an enabling environment that encourages and drives progress. After putting this foundation in place, cities expand quality and coverage of service through greater efficiency and partnerships. Sustainable cites are supported through local and global connectivity and a strong capacity for resilience, disaster preparedness, and proactive disaster risk reduction. Our understanding of sustainable cities in this report is linked with this framework, which aims to provide a simple model for a development path toward a sustainable city.

The Urban Ecosystem

Another way of understanding what makes a city sustainable is through the analogy of the urban ecosystem. A biological ecosystem has been defined as a community of living things interacting with nonliving things (Chapin et al. 2002; see also Box 6). In an urban ecosystem, people are among the living things, and the buildings, streets, and other built structures are among the nonliving things.

FIG. 4
Hierarchy Model for Developing a Sustainable City



Source: Henry Jewell/World Bank

BOX 6

Photo: Curt Carnemark/World Bank

Ecosystems and Ecosystem Services

An ecosystem can be described as a natural area that functions as a unit consisting of components (such as plants, animals, micro-organisms, water, air etc.), and the interactions between them. Functioning ecosystems are the foundation of human wellbeing and most economic activity, because almost every resource that humankind utilizes on a day-to-day basis relies directly or indirectly on nature. The benefits that humans derive from nature are known as ecosystem services, which can be divided into four categories: provisioning services (what we consume directly), regulating services (what protects us from extreme events), cultural services (natural systems that we use for recreation, religious or spiritual purposes), and supporting services (the underlying processes that deliver the other services). Ecosystem management has long been recognized as a key component to sustainable development and poverty alleviation, with the use of sustainable resource management in urban and peri-urban areas shown to provide livelihoods for communities throughout the world.

Source: Reprinted from Morcotullio and Boyle (2003).

The Urban Long-Term Research Area (ULTRA) program in the United States is now studying the ecological flows and interactions in cities. Researchers at Boston University, for example, have discovered a "weekend effect" on emissions—a steep dropoff in the amount of carbon dioxide entering the city's atmosphere on Saturdays and Sundays. In Fresno, California, backyard water use increases with wealth, as does backyard biodiversity. In Los Angeles, ecologists studying the city's "ecohydrology" have calculated that planting a million new trees, an idea with fairly universal appeal, would have the drawback of increasing water consumption by 5 percent.

In recent years, an ecosystem approach has become more widely used in city management. Adopted by the UN Convention on Biological Diversity (CBD) (Ibisch, Vega, and Hermann 2010; Smith and Maltby 2003), the ecosystem approach is a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. The rise of this type of strategy is due in part to the 2005 Millennium Ecosystem Assessment (MA 2005), which concluded that human impacts on the health and biodiversity of world ecosystems are significant and escalating. In the wake of this report, a variety of innovations—breakthroughs in the understanding of ecosystem dynamics, green paradigms in economics (Boxes 7 and 8) and in building design, and new financial mechanisms—have allowed for more policymakers, including urban managers, to consider taking an ecosystem approach.

Urban management using the ecosystem approach recognizes that a city is a component of one or more ecosystems, and thus city managers must consider variables beyond the city borders when defining and implementing policies (see Box 9). Ecosystem thinking can bring broad benefits across the three pillars of sustainability; for example, by highlighting the value of natural capital and the dependence of poor populations on well-functioning ecosystems (MA 2005), it helps cities balance socioeconomic concerns with environmental protection.

BOX 7

Economic Valuation of Ecosystem Services

The economic valuation of ecosystem services is an emerging science that has seen experts attempt to quantify the contribution of such services to the local or national economy. While the process is challenging, it allows policy makers to propose policies relating to the natural environment that can be weighed against other competing activities, such as large-scale infrastructure development. For instance, in Chicago, USA, urban trees are estimated to provide a service for air cleansing that is equivalent to US$9.2 million dollars, and their long-term benefits are estimated to be more than twice their costs.

Source: Reprinted from MacPherson et al. (1994).

Photo: ©Bigstock

Payments for Ecosystem Services

BOX 8

Economic considerations have helped in the development of payments for ecosystem services (PES)—the practice of offering transparent, voluntary incentives to landowners in exchange for managing their land to provide some sort of ecological service. PES programs promote the conservation of natural resources in the marketplace.

The ecosystem services that these schemes usually focus on are climate change mitigation, watershed services, and biodiversity conservation, all of which are subject to growing demand. Some PES schemes involve contracts between consumers of ecosystem services and the suppliers of these services, but the majority are funded by governments and also involve intermediaries such as NGOs. The party supplying the environmental services normally holds the property rights over an environmental good, which provides a flow of benefits to the demanding party in return for compensation. In the case of private contracts, the beneficiaries are willing to pay a price that can be expected to be lower than their gain in welfare due to the services. The providers of the ecosystem services can be expected to be willing to accept a payment that is greater than the cost of providing the services.

Photo: Curt Carnemark/World Bank

BOX 9

Case Study: Urban Freshwater Resources in Los Angeles

In 1900, Los Angeles, California obtained all of its water from the Los Angeles River, but population growth (primarily due to in-migration) caused the city's needs to exceed this local water supply early in the 20th century. The system was then extended to other water basins up to hundreds of kilometers away. The ecological impacts of this expanding water-supply system have been serious and widespread. By the mid-20th century, the natural Los Angeles River ecosystem had become severely degraded by a combination of agricultural and municipal water use, water pollution, and flood control structures. Reduced freshwater inflows have seriously degraded the wetlands and once-productive fisheries, while other effects included the creation of dust storms that affected local residents.

A series of lawsuits throughout the 1970s and 1980s forced the urban authorities to restore flows and wildlife habitats, mitigate dust storms, and limit water exports to allow lake elevations to return to more natural levels. These events marked the beginning of a transition in Los Angeles' water-supply sources and water demand. Following a lengthy drought from 1987 through 1992, Los Angeles began to invest seriously in reducing water demand; as a result, per capita water usage decreased by 15 percent between 1985 and 2000. The city's population is projected to grow from 3.8 million in 2000 to 4.8 million people in 2020 and future increases in demand are to be met through water conservation and recycling.

Source: Reprinted from Fitzhugh and Richter (2004).

Resource efficiency—the sustainable use of resources throughout their life cycle, including extraction, transport, consumption, and waste disposal—is often the primary goal for officials exploring an integrated approach to city management. There is a strong link between natural resource management and well-being in cities. Resource efficient cities combine greater productivity and innovation with lower costs and reduced environmental impact.

With increased pressure on natural resources, city policies need to maintain and capitalize on those resources. For instance in Melbourne, Australia, a network of regional parks, trails, foreshores, and waterways contribute significantly to the city's livability and public health. Local park agencies have partnered with a major health insurer and invested over US$1 million in a program for health care professionals to encourage people to increase physical activity by visiting and engaging in activities in these areas (TEEB 2011). In contrast, neglect of natural resources can have dire consequences. Ulaanbaatar, Mongolia, depends on the watershed of the Upper Tuul valley, which is rapidly degrading. The reduced availability of water and other ecosystem services, business-as-usual management, and increasing degradation will result in an estimated cost of $300–500 million to industry, and reduced economic growth prospects for the city over 25 years.

How Can Cities Be Made More Sustainable?

The complexity of urban systems and the close links between economic, social, and environmental objectives raise challenges in designing good urban policies, as trade-offs are inevitable. For instance, an ambitious economic strategy in a city may be hindered if the city cannot provide low-income housing and adequate transportation for workers who will be attracted by jobs. Cross-sectoral cooperation is key for integrated economic development in cities. There are also significant opportunities to bring about equitable and inclusive development under the umbrella of green growth. The informal sector provides both an immense labor resource as well as a market for green services and products. Therefore, the job opportunities created by green industries can and should include the urban poor.

Policies that correct environmental issues may have negative or positive side-effects, leading to either tradeoffs or synergies. For instance, a transportation policy that decreases congestion improves inhabitants' well-being, enhances economic attractiveness, reduces inequalities in accessibility among neighborhoods, and lowers air pollution. On the other hand, reserving urban land for public parks or green spaces without providing compensatory measures may lead to reduced population density, increased greenhouse gas emissions from transport, and higher land prices.

These conflicts create implementation problems, while synergies offer opportunities for win-win solutions. To identify and capitalize on these opportunities, cities and their partners can:

- **Address Knowledge Gaps.** There are massive gaps in terms of knowledge, analytics, indicators, and local government capacities, particularly for dealing with complex issues on multiple timescales (see Chapters 5 and 6). The lack of institutional capacity will be especially limiting when it comes to choosing among technical packages, negotiating with suppliers of so-called green technology, and ensuring community participation when understanding of the global "bads" remains minimal.

- **Foster Participation.** A city's metabolism (the flow of materials and energy into and out of a city; see Chapter 5) results from the interactions of many stakeholders, including city officials, inhabitants, nongovernmental organizations (NGOs), and businesses. Sustainable urban policies will depend on the contributions of both public and private actors, and on incentives to guide individual private action, including funding, innovative new technologies, and sharing of information (see Chapters 6 and 7).

- **Seek Behavioral Change.** Most importantly, sustainable development calls for changes in individual and corporate behavior. Influencing human behavior is possible—for instance, through the provision of information on energy cost-saving measures. Cities can set their long-term objectives (for example, reduce 20 percent of energy consumption over 20 years) and help private actors plan and contribute to these objectives[5]. The role of the private sector is particularly important in supplying greener goods and services, retrofitting buildings, and enabling cities to increase density and improve the efficiency of service delivery (see Chapter 6).

The above interventions require strong institutions and an effective regulatory framework, discussed in Chapter 6. To motivate these institutions and policies, however, an economic case needs to be made for sustainable cities. The next chapter explores how green investments relate to urban prosperity and growth.

Further Reading

Annex 1 shows projected growth in urban populations.

Annex 17 reprints the Sustainable Development Goals agreed at the 2012 Rio+20 summit.

[5]See the case of Mexico City, which has worked with World Resources Institute and WBCSD and has obtained the cooperation of firms who contribute 30 percent of the city's greenhouse gas emissions. New York's sustainability program, announced in 2006, is another good example of effective city strategies for sustainability (Newman and Jennings 2008).

2 Economics of Green Cities

Key Messages

- **Green policies pay dividends both in the short and long run. They can not only reduce pollution and waste but raise well-being and speed economic growth.**
- **For example, city form profoundly influences greenhouse gas emissions and urban sustainability as well as economic productivity and efficiency. Dense cities that are served by integrated public transport systems can have high prosperity with relatively low emissions.**
- **While green investments may be profitable, market uncertainty in the short term will require support from the public sector to compensate for lack of information.**
- **An economic downturn may be an ideal time for public investments in sustainability, which can boost productivity and employment .**

As the world seeks to recover from the 2008 financial crisis and the subsequent sovereign debt hangover, the focus has inevitably shifted away from designing climate policies and other steps toward sustainable development. But the need for long-term policies is as acute as ever, especially in cities that are rapidly building up infrastructure. In fact, investing in sustainable choices for cities can be economically rewarding, feasible and prudent even in a bad economy. Investments and business partnerships at the city level will be a crucial ingredient in green growth that reduces poverty while protecting natural resources (Box 10).

Photo: Julianne Baker Gallegos/World Bank

BOX 10

The Push for Green Growth

Photo: Shutterstock

Several multilateral institutions have launched initiatives to address the challenges of climate change while providing for the needs of some 2 billion poor people (UNEP 2011; OECD 2011b; World Bank 2012a). "Green growth" is about making growth processes resource-efficient, cleaner and more resilient without necessarily slowing them (Hallegate et al. 2011).

Protecting the environment contributes to national income in different ways. First, "natural capital" is part of production. Environmental conservation increases natural capital, and hence income. Second, environmental assets are generally prone to market failures—externalities and ill-defined property rights are common—and correcting these market failures can increase the effective supply of natural capital. It can also improve human well-being directly or indirectly. For example, alleviating traffic congestion directly reduces air pollution, but also indirectly improves the productivity and economies of scale typically offered by cities.

The UNEP report Towards a Green Economy (UNEP 2011) shares some encouraging news. First, "investing two percent of global GDP into 10 key sectors could kick-start a transition to a low carbon, resource-efficient Green Economy."[a] Second, the shift of resources would not only preserve economic growth, but could enable a higher growth rate, as it would promote new activities and increased job creation. Third, the problem at stake involves more than trade-offs between growth and environment; it is mostly a "gross misallocation of capital." If $1.3 trillion (less than 10 percent of the world's annual investments) were redirected to green investments, growth and poverty reduction would be achievable, while simultaneously promoting a more sustainable economy.[b] Such a green economy is not only relevant in developed economies but is also a catalyst for growth and poverty reduction in developing countries[c].

Green growth encompasses not only traditional industries that are becoming less resource-intensive, but also entirely new industries that provide services such as reducing pollution or producing green power. These create new products, new jobs and new collaborative strategies (OECD 2011b). Emerging green industries present opportunities for countries such as China and India, which are now industry leaders in wind and solar power, and Brazil, the world leader in biofuels. Morocco and other North African countries are investing heavily in concentrated solar energy, with the hope of developing a domestic industry. At the city level, the rapid expansion of new towns brings enormous opportunities for planning and developing denser and more efficient cities, improving urban transport and preventing slum formation. This kind of growth is compatible with the idea of a green economy that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities.

a. The 10 sectors include agriculture, buildings, energy supply, fisheries, forestry, industry, including energy efficiency, tourism, transport, waste management, and water.

b. This $1.3 billion is roughly equal to the amount of subsidies spent in fossil fuels (UNEP 2010).

c. An investment of 1.25 percent of global GDP each year in energy efficiency and renewable energy would cut primary energy demand by 9 percent in 2020 and 40 percent in 2050. Savings on capital and fuel costs would average $760 million per year between 2010 and 2050.

Urban Density, Efficiency, and Productivity

To address complex environmental problems while sustaining growing consumption, cities need to consider their urban design and the policies that affect spatial form and density. Density has been found to affect both productivity and efficiency: Some studies suggest that, controlling for other factors, a doubling of density can add from 6 percent to 28 percent productivity (Avent 2011). In contrast, others argue that families flee city centers because of opportunity costs from high density—but this may depend on the city's history of spatial development (Box 11),

In addition, dense cities tend to have lower per-capita emissions, provided that they are also served by good public transport systems (Hoornweg, Sugar, and Gomez 2011). Cities with limited urban sprawl and integrated urban transit systems, such as Barcelona and Singapore, have become affluent while keeping their per capita emissions low (see Chapter 5 for a comparison of emissions and GDP among large cities). Their relatively low resource intensity is mainly a result of greater transport energy efficiency (due to reduced distances and greater shares of public transport modes). Burdett (2011) reports that compact cities such as Vienna or Barcelona have significantly higher population densities, higher public transport use, and correspondingly lower per capita emissions than sprawling cities such as Atlanta and Houston.

Higher density also enables more energy-efficient heating and cooling in buildings and lower embedded energy demand for urban infrastructure. The savings in operating costs from shorter transport networks and less diffuse utility infrastructure can amount to thousands of dollars of annual savings for the average household (Litman 2013). And compact, well-managed cities with intelligent infrastructure can be more attractive to walkers than suburban or rural communities. Inner-city Barcelona, London, Paris, and Rome, together with New York, Singapore, and Tokyo provide examples of creative, growing city centers with access to a variety of amenities, including green space.

Historically, urban density (or sprawl) has mostly not been determined by policy. Some cities are based on medieval or ancient road plans. Others have been developed for car travel on the basis

BOX 11

Do Families Prefer the Suburbs?

Some economists argue that low urban density is preferable based on "hedonic estimation"—that is, people's subjective preferences. Families may accept lower wages and higher commuting costs in order to live away from city centers and afford larger living quarters, for example.

As with all issues of path-dependency, people's preferences will depend on how spatial development unfolds over time. In cities such as Cleveland, Pittsburgh, Buffalo or Detroit in the United States, as in several Latin American capitals, suburban sprawl has drawn wealthier car-owning families away from inner cities that can then become run-down, poor, and crime-ridden (the so-called hollowing-out effect). In other cities, however, wealthy people congregate in the city centers and tolerate high housing costs precisely because of a superior living environment. This supports high-quality housing, amenities and a wealth of cultural opportunities. Examples exist across the world, from Paris to Hong Kong, Tokyo to New York. Nonetheless, suburban living remains popular, and cities need to be carefully planned in order to attract wealth-creating individuals.

of land-intensive suburbanization. Highly dense cities such as Barcelona and Manhattan have had their scope for sprawl limited by the constraints of oceans and mountains, as well as strong public policy and local interest in compactness.

Whatever the reason, once an urban form is chosen and locked in it will determine the pattern of a city's resource intensity for decades, or even centuries. When densities are too low, bike lanes or bus systems, for example, become too expensive and unappealing. It is probably too late to make Phoenix and Atlanta efficient, dense cities—but measures such as road pricing, bus lanes on highways, electric vehicle infrastructure and distributed low-carbon energy networks can reduce carbon footprints, improve energy efficiency and promote innovation in resource-intense sprawling cities. Some of these cities, such as Los Angeles, have been able to promote denser forms within the urban core.

Exogenous variables such as the increase in fuel prices, financial crises, and changing cultural and generational tastes will strongly influence how future cities organize. Most likely, many of those factors will reinforce each other. For example, the New Urbanism movement of the 1990s has insisted for decades on the return to mixed-use residential areas and compact cities (Congress for the New Urbanism 2001). These ideas have found a fertile ground amidst the planning profession as the hike in fuel prices has made commuting an often unaffordable proposition and car-dependent suburban houses much less attractive. This was the case in Victorville, 100 miles northeast of downtown Los Angeles, where inhabitants were entirely dependent on private cars to connect homes to work and services (Karlenzig 2011). With the rise in fuel prices, some of Victorville's suburban neighborhoods have been demolished.

Many scholars predict the end of sprawl and the emergence of a decentralized urban form, based on the replacement of the private car by efficient public transportation and light rail, as in European countries. Lessons from our collective experience with urbanization should be used to support developing cities that are expected to grow exponentially.

Co-benefits of Reducing Greenhouse Gas Emissions

Implementing sustainability strategies often pays short-term economic dividends. Greenhouse gas reduction plans can drive efficiency and allow cities to reduce waste and cut costs. Cities offer a unique environment to innovate, develop and scale up new ideas and processes, promoting the growth of knowledge-intensive green production sectors. Urban economies of scale offer the opportunity to develop green investments such as integrated public transit, sewers and water systems, congestion pricing, smart grids, smart buildings and decentralized energy networks (Sedgley, Norman, and Elmslie 2004). Especially in OECD countries, some cities have become laboratories for action on climate change, in which growing experience leads to further innovation and lowers the cost of new technologies. Urban regions already produce 10 times more renewable technology patents than rural regions (Kamal-Chaoui and Roberts 2009, p. 16).

Climate policy also yields other collateral benefits at the local level, and conversely, investment in attractive and successful cities will yield climate benefits. Low particulate pollution reduces health care costs, increases city attractiveness, and promotes competitiveness. Similarly, reduced waste makes for a more attractive environment (with fewer and smaller landfills, for example), while renewable energy sources enhance energy security (Hallegatte et al. 2008). Policies to increase vegetation and green spaces not only reduce the heat island effect, but also improve resilience to flooding. Low-carbon transportation means fewer traffic jams and accidents as well as cleaner air

BOX 12

Case Study: Benefits of Bus Rapid Transit in Bogotá

Bogotá's investment in the Transmilenio Bus Rapid Transit system has brought important benefits, including reduction in travel times, diminished congestion, reduced carbon dioxide emissions, and increased mobility and access to labor markets (Montezuma 2005). Further, the scheme was designed to connect the 13 major slum areas around the capital city. Health benefits from green transport strategies are also significant, as they include emission reductions, increased physical activity levels, and road safety. Health and safety benefits have been estimated to exceed the cost for integrated non-motorized and public transport measures by a factor of 5 to 20 times in cities as diverse as Bogotá, Delhi, and Morogoro (Dora 2007).

Photo: Shutterstock

Photo: Julianne Baker Gallegos/World Bank

and healthier people (Box 12). Efficient and green cities are likely to draw communities together as they provide better places to live and generate economic prosperity. Because of these synergies between sustainability and livability, the returns to complementary, integrated policies are multiplied—the sum is greater than the parts.

Incentives, Business Opportunities, and Challenges

Opportunities in low-carbon investment have been estimated at $500 (€367) billion per year and rising, with clean energy investments in 2008 totaling $177 (€130) billion (UNEP and New Energy Finance 2010; see also Box 13). Once new markets are created with supportive policies and a favorable legal and regulatory environment, innovative businesses can explore this growing field. New activities will include higher-end business services, such as environmental consulting. Clearly, opportunities will vary across cities according to income levels, human capital, and comparative advantages for low-carbon transition.

While public finances remain stretched since the economic crisis of 2008, there are sufficient private resources that could be invested in green urban technology, were it not for the perceived lack of opportunity and confidence (Romani, Stern, and Zenghelis 2011). However, although there is evidence that green cities and prosperity go hand in hand, private companies acting in their own self-interest are not always best placed to benefit from these synergies. Public incentives remain necessary to encourage greener practices and industries, as green growth endeavors may have a number of problems attracting investment and producing profits:

- The payback from an up-front investment in energy efficiency is not immediate, sometimes accruing beyond political cycles or over uncertain and long periods that deter private investors. For efficient consumer appliances, even where payback periods are short, many buyers face financial constraints in making the initial investment.
- These investments also carry significant policy-related risk, as the financial returns from energy efficiency will depend on energy and emissions policies.
- The trade-offs between more expensive renewable energy and less expensive polluting fuels are difficult to measure or quantify, and consumers may be inclined to favor the cheapest solution in the short-run.
- Profitable investments may be precluded by low liquidity and lack of capital to finance upfront investment and compensate for short-run losses.

Clean Energy Investments Surging

Even in the present uncertain environment, with a lack of ambitious and coordinated global green policies, investment in renewable energy generation and energy efficiency is surging.

- Investment in this sector has quadrupled since 2004, according to Bloomberg New Energy Finance (BNEF) (Zenghelis 2011c). New investment in clean energy surpassed investment in conventional energy generation in 2010, rising to between $180 and $200 billion.
- Two of the world's fastest-growing economies, South Korea and China, moved decisively to embrace high-technology, low-carbon growth in their stimulus packages in 2008 and 2009, and in China's outline for its Twelfth Five-Year Plan. Of the seven "magic growth sectors" identified in the Twelfth Five-Year Plan, three are low-carbon industries: clean energy, energy efficiency, and clean-energy vehicles (the other two sectors are in high-end manufacturing).

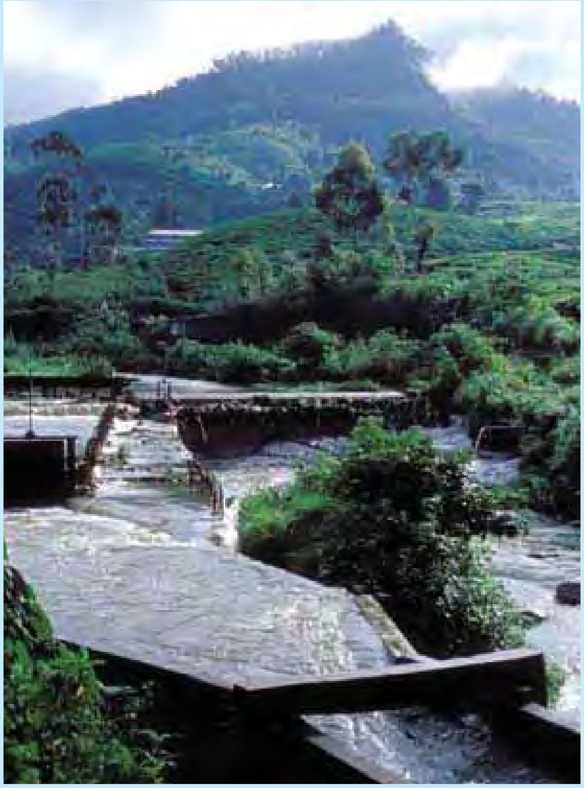


Photo: Dominic Sansoni/World Bank

BOX 13


Photo: Dominic Sansoni/World Bank

- Finally, the potential gains from investment in energy efficiency and renewables may not yet have been recognized.

As fossil fuels and other scarce resources continue to rise in price, and as the policy environment addresses inefficiencies, this should change. However, even where clear gains have existed in the past, there have been several additional barriers preventing optimal investment in resource efficiency:

- There are often split incentives where the benefits of energy savings do not accrue to the individual or group making the investment (the landlord, construction firm, or property seller, for example).

- Efficiency gains that boost productivity in the long run often threaten individual jobs, triggering political resistance.

- Weak monitoring and measurement systems make it hard to manage and monetize the gains from efficiency investments—for example, few consumers have smart meters to alert them to energy use and waste—which reduces the incentive to invest.

- Research in renewable energy is often long-term and speculative, carrying many risks, with knowledge spillovers that are hard to monetize or patent. Consequently, innovation has often fallen short of the social optimum.

- Finally, a lack of expertise often hinders the speed of the change in the urban environment.

Despite these barriers, cities increasingly lead the field in changing the public perception in favor of sustainable policies, often influencing even the national agenda. Examples include congestion charging in London, car sharing in Berlin, and planning and policy leadership in Bandung, Barcelona, Brisbane, Guelph, Nanjing, and Portland, many of which set the standard within their countries. As discussed in the previous chapter, central and local government agencies are often best positioned to prompt behavioral change by engaging a well-informed population.

Thus, public intervention with a popular and clearly understood mandate is essential for addressing the market failures associated with urban sustainability (Rode et al. 2012). Credible policy signals at the city level can leverage private investment in renewable energy, smart networks and communities, energy efficiency, and low-carbon vehicles while stimulating the local economy. One good opportunity is targeted public procurement, which affords cities a chance to shape markets and incentivize innovation on low-carbon products and services (Stern 2010).

With output remaining below capacity and the cost of capital at historically low levels, there is less fear of crowding out alternative investment or displacing jobs. While the private sector may remain cautious, some 82 percent of cities report that climate change represents an economic opportunity for their city; the most commonly reported opportunity is green jobs (reported by 40 cities), closely followed by development of new business and industries (reported by 39 cities) (CDP 2012).

Recession Investing and Sustainable Finance

Among the other co-benefits of sustainable cities, planning policy can also influence the macroeconomic environment. During economic downturns, urban infrastructure and retrofitting can boost job creation and stimulate activity, especially in "shovel-ready" sectors such as building efficiency retrofits, broadband infrastructure, and retooling manufacturers. In the present environment, there is an opportunity to take advantage of the record pool of private savings, provided the investment packages have adequate returns for private investment funds (Zenghelis 2011b). Public funds could be used to leverage, guarantee, or otherwise improve the attractiveness of clean and green investments to the private sector. But this will require creativity in planning and designing new financial instruments to encourage sustainable urbanization.

Indeed, now may be an ideal time to invest in a sound long-term growth strategy and to address the basic market failures hindering green urban investment. It is a myth that recessions are a bad time to plan green investments because they add to business costs.

For a city to be sustainable in the long run it must diversify its capital base and generate cash flow for reinvestment. Although multiple sources of capital are available to city governments and businesses—including public, private and developmental capital—urban sustainability initiatives often fail to secure the investment they require. To access new sources of finance, cities need to create conducive policy and investment environments and articulate the value of their sustainability initiatives in

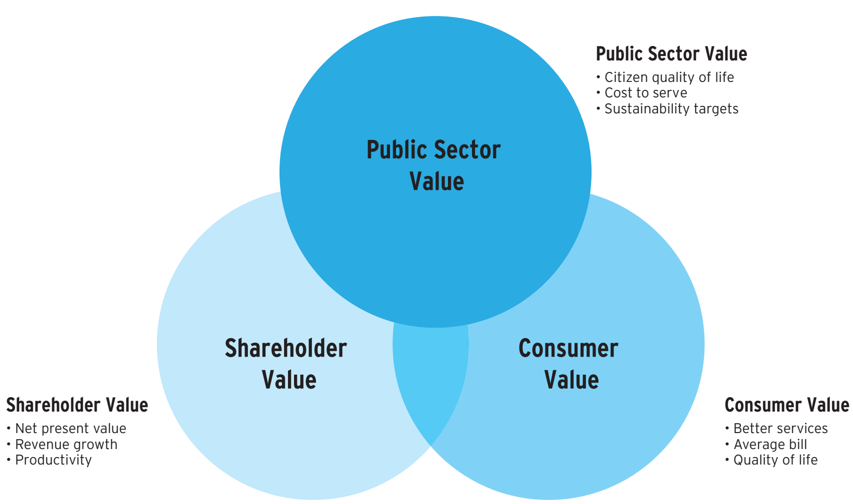


FIG. 5
Value of Urban Sustainability Initiatives for Different Stakeholders

Source: Adapted from Arup et al. (2011).

terms that interest each investor. For example, the private sector will care about revenue growth and productivity, the public sector about cost-to-serve and sustainability targets, and citizens about bill savings and well-being (Figure 5).

Social Impact Bonds[6] in the UK are an example of how to foster a common perception of value. The UK government created an outcome-driven system for solving societal issues that aligns public sector funding with private sector incentives so that there is a mutual benefit from the improved outcomes.

The Need for Knowledge

To take full advantage of the economic benefits of green policies, cities will ultimately need a better-developed research base. As we have seen, there is mounting evidence that measures that make cities work better in terms of emissions and sustainability also make them more prosperous and attractive. These data need to be collated in order to develop a fuller understanding of the policy mixes that can lead to successful, resource-efficient cities. However, problems of data compatibility and reliability, and ultimately the fact that no two cities are alike, make the analytical task a challenge. These issues are discussed in Chapter 5.

First, though, we will explore the types of interventions that need to be studied—the best opportunities for making cities cleaner, more efficient, and more prepared for climate change and other shocks. There is no one-size-fits-all solution for complex and heterogeneous cities, but all have scope to increase efficiency, make greater use of renewable resources, and improve the environment for innovation, with significant economic as well as environmental returns. The investments and strategic decisions made over the next few years will determine where the winners and losers will be in rising to the challenge of a sustainable future.

Further Reading

Annex 16 describes the World Bank's Eco2 Cities Initiative, which helps cities design development pathways for both ecological and economic sustainability.

[6]http://ukpolicymatters.thelancet.com/?p=1323

PART II.
The Path to Sustainability

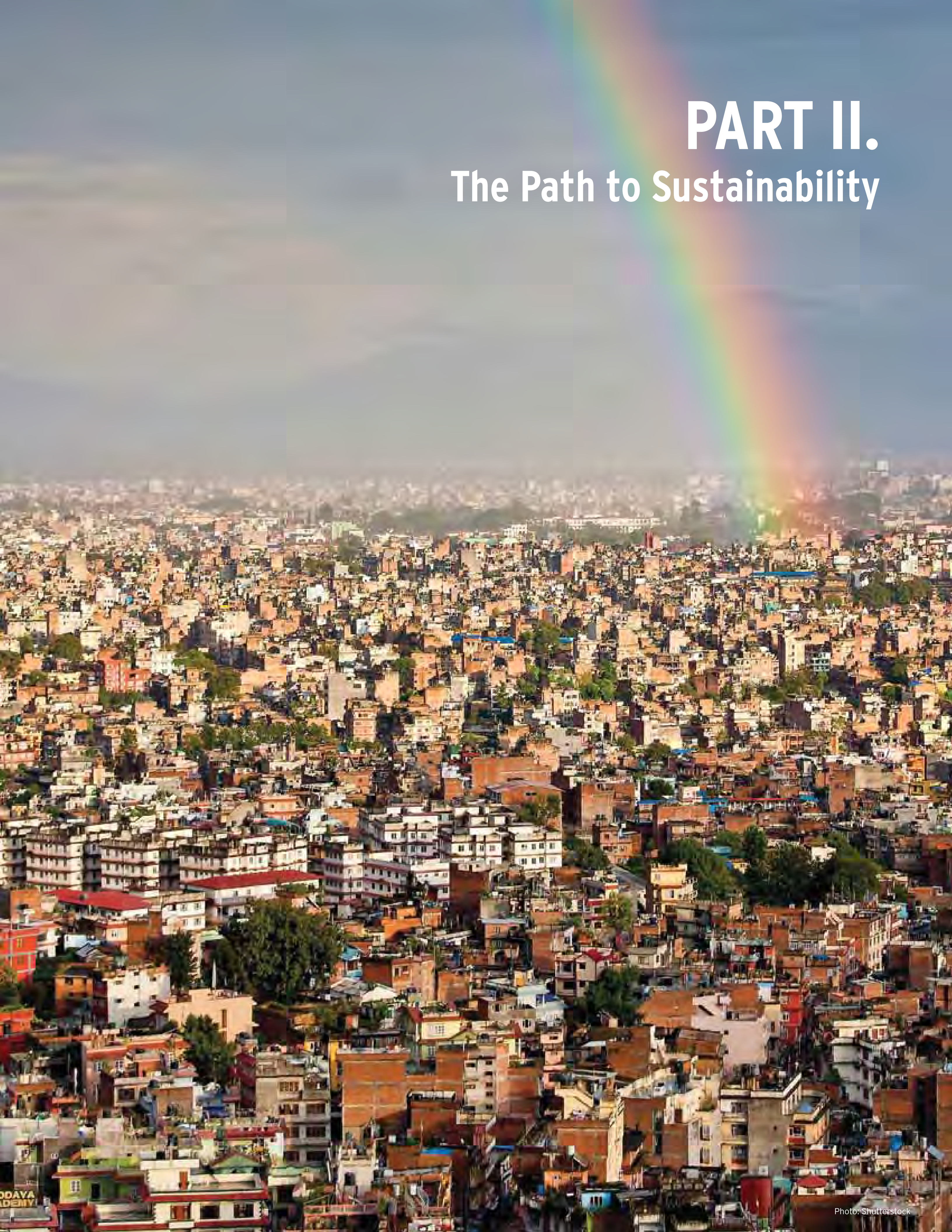


Photo: Shutterstock

3 Building Clean and Efficient Cities

Key Messages

- **Land and housing regulations as well as market-based incentives can be used to encourage compact, efficient cities.**
- **Rapid urbanization, particularly in Africa, the most rapidly urbanizing continent, presents the risk of uncontrolled sprawl as well as the opportunity to transition directly to more sustainable infrastructure.**
- **Cities are the primary global energy consumers. Both developed and developing country cities need to enact policies that increase energy efficiency and promote cleaner energy sources for electricity generation, buildings, and urban transport.**
- **Buildings constitute the largest opportunity to improve demand-side energy efficiency. Green building standards target the operational phase of building life, while embodied energy in buildings can be conserved through the adaptive reuse of historic built assets.**
- **Emissions from transport are likely to increase dramatically as demand for private transportation grows in the developing world. Transport sector investments need to provide a viable alternative to automobile use.**
- **Waste generation is increasing in quantity and complexity with urban growth. Municipal solid waste generation is unlikely to peak before 2100, and this will exacerbate shortfalls in municipal budgets to collect and properly dispose of waste.**

Cities can take advantage of their massive growth in the coming decades to become more livable and sustainable, but they will need to move quickly and target the sectors and policies that have the greatest influence on resource-efficiency, greenhouse gas emissions, and other pollution. Rapid growth will necessitate a supply of serviced land and affordable housing, embedded in a city form that serves the economic needs of the community. It will be necessary as well to invest in connective infrastructure and basic services that have the lowest possible resource intensity.

An essential starting point for growing cities is the urban form, shaped by land and housing policies. As discussed in Chapter 2, urban density or sprawl broadly affect efficiency and economic productivity. In addition, three urban sectors—energy, buildings and transportation—are responsible for the bulk of global greenhouse gas emissions and deserve priority in analytical inquiries and policy actions. Urban electricity, heat, and cooling together contribute 37 percent of global energy-related emissions, buildings contribute 25 percent, and urban transportation contributes 22 percent (WRI 2009). Water and solid waste management are also central to sustainable cities. Box 14 reviews how the key areas could be addressed in an emerging economy like China, and Figure 6 shows the top actions taken by cities in the C40 network.

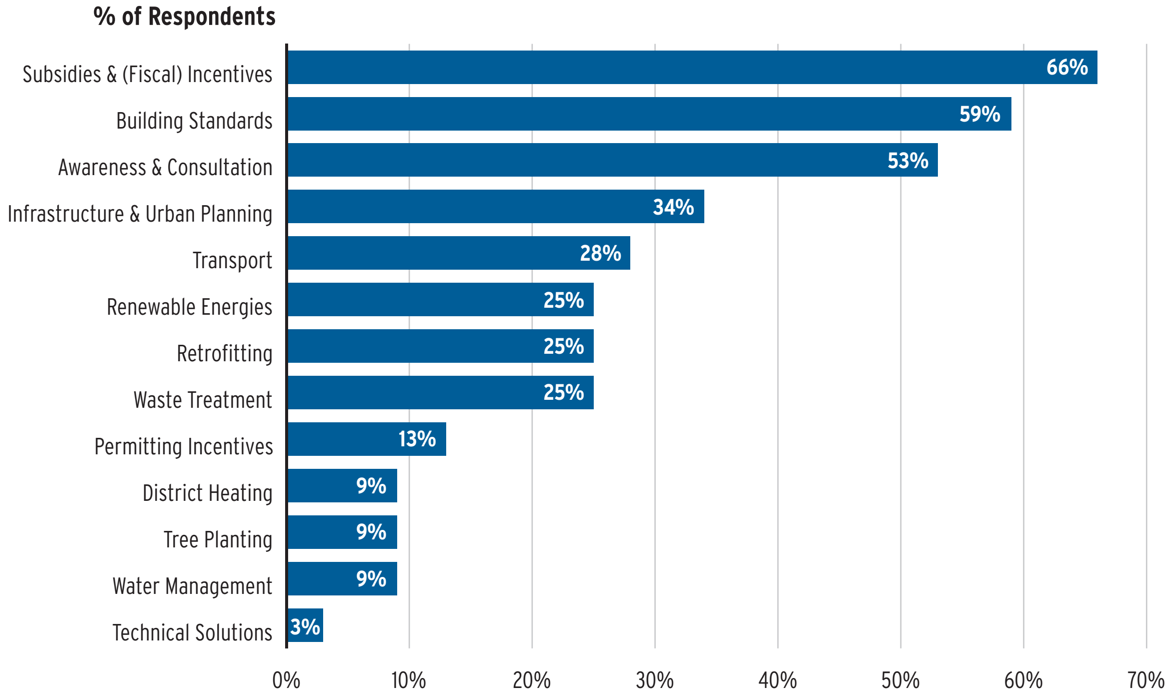


FIG. 6
How C40 Cities are Reducing Emissions

Source: Adapted from CDP (2011).

BOX 14

Case Study: Low-Carbon Urban Development in China

Chinese cities have among the highest levels of per capita greenhouse emissions in the world. As millions of people migrate to cities over the next 20 years, China will need a strategy to curb carbon emissions in urban areas. The following elements are essential building blocks of such a strategy:

- ***Increasing energy efficiency and use of clean energy sources:*** Cities should make an effort to reduce carbon emissions by sustaining demand-side energy efficiency measures, particularly in industry, power, heating and buildings. In addition, cities could develop clean sources of energy supply with rooftop solar PV and solar water heating installations.

- ***Reducing transport sector emissions:*** To minimize emissions from the transportation sector, reduced motorization will be required. Decisive action should be taken both to adopt new technologies and provide high-quality public and non-motorized transport.

- ***Managing cities' physical growth:*** Cities need to intervene in the shape and direction of their physical growth. Cities with higher densities emit less greenhouse gases. Cities not only need to grow denser but also smarter, fostering compact communities, multiple-use buildings, and public transport networks.

- ***Support of low-carbon lifestyles***: With rising income and higher individual purchasing power and consumption demands, a low-carbon lifestyle will be a key determinant of future energy demand in Chinese cities. Some tools have been developed internationally to engage citizens in understanding their household carbon emissions and taking action to reduce them. Similar partnerships at the city and neighborhood level in China could contribute to less carbon-intensive households.

- ***Replacing energy-intensive manufacturing with low energy intensity economic activities:*** Changes in the urban economic base, such as a transition to service industries, will reduce emissions. However, such strategies need to be considered carefully. For today's industrial centers, simply relocating higher emission industries outside a city boundary to reduce the greenhouse gas emissions of that city would make little (if any) difference on the national scale. However, rapidly growing small and medium-sized cities may have the opportunity to leap-frog and bypass the polluting, high-carbon growth paths taken by the earlier generation of Chinese cities.

Source: Reprinted from World Bank (2011b).

Land Management and Policy

The supply of affordable, serviced land is probably the most important input for sustainable urbanization. The World Development Report 2009 (World Bank 2009) explicitly mentioned the importance of good land markets to enable the effective expansion of urban agglomerations and the mobility of production factors. For countries in the earlier stages of urbanization, land management is particularly important as records and titles are often missing, legal systems are fragmented and inconsistent, and private interests may lead to speculation and corruption as urban expansion increases demand for usable land. Tenure reform or systematizing land titles can bring major benefits in such cases (Box 15).

To ensure the design of a good local development plan, cities need knowledge, a commitment to sustainability, and an understanding of how density, infrastructure, and the use of transport alternatives contribute to emissions and sustainability. To implement such a plan, local authorities need to have good land records, titles, policies, and the authority to allocate land and establish the rules as manifested in zoning laws, adequate floor area ratios and height limits, and building codes. Thus, the key pillars of urban planning include good land records and titling, a good understanding of how the city is growing, the preferences of the residents and businesses, and knowledge of how zoning and transport systems can work together to enable the implementation of the plan (Box 16). Cities would be best advised to understand how to deploy market incentives to promote growth in the desired direction (Box 17).

Typical regulations that affect land availability include zoning, minimum lot size, floor area ratios, and height limits. Often, land or housing regulations become constraints to a quick and responsive supply of urban land. Minimum lot sizes, minimum frontage, and the percentage

BOX 15

Case Study: Systematizing Land Titles in Africa

Africa used to be the continent where land systems were complex and where standardized title systems were usually absent. In the last few years, however, progress has been remarkable. Several African countries have made impressive progress in recognizing traditional and modern titles and in improving land records and transaction deeds. This not only offers a solid basis for property taxation, but provides the public sector with the fundamental tools for land-use planning and urban infrastructure development.

Photo: Julianne Baker Gallegos/World Bank

Photo: Jorge Láscar

BOX 16

Connecting Transportation and Land-Use Planning

Successful cities such as Seoul and Curitiba have promoted urban development around public transportation and amenities (Curitiba), or around urban core areas (Seoul), relying on transportation linkages, mixed land uses, and high-quality urban services. Land-use zoning policies that allow for higher densities and greater mixing of residential and commercial uses enhance transportation goals by reducing trip distances, while strategic mass transit linkages can attract development and promote compact growth. However, density can also be perceived as a cost—crime and violence tend to be higher in dense places, and local traffic is worse. These costs must be outweighed by the benefits of agglomeration and urban amenities, including proximity to high-quality public transportation (Cheshire and Magrini 2009). Long-term growth plans aim to strike this balance in a number of OECD metropolitan areas, including London, New York, and Paris.

Photo: Shutterstock

of plots allocated to public infrastructure effectively limit the supply of serviced land. In highly urbanized countries, land policies continue to shape environmental, social, and economic outcomes. Misguided regulations or inelastic land supply often lead to unaffordable land and housing prices in the center of the city, pushing out the working class and low-income households. Lack of sufficient transportation compromises the livelihoods of new urban residents.

While zoning and other regulations are necessary to preserve the planned use of land, the usual result is to push residents to the urban periphery, which eventually leads to sprawl. Recognizing this, many cities have started working to reverse the constraints that bring about sprawl and decentralization. In this vein, it is also crucial that urban planning take account of informality. Due to a lack of information, commitment, or knowledge, many developing cities plan the "official city" and neglect

BOX 17

Market-Based Incentives for Land Policy

Market-based incentives and regulatory frameworks are the key ingredients of good land policy. In the case of development density, market-based incentives should begin by dismantling old regulations that promoted sprawl. For example, in the U.S. state of South Carolina, nonessential regulatory requirements on housing[a] were eliminated in order to encourage affordable housing, traditional neighborhood design, and density. These market-based incentives included density bonuses to promote densities higher than typically permitted; relaxed zoning regulations regarding lot area requirements, minimum setbacks, yard requirements, variances, parking requirements, and street layout; reduced or waived fees, including fees levied on new development; streamlining and expediting the permitting process; and traditional neighborhood design to promote high density and mixed-use development.

Transferable development rights (TDR) programs operate through the transfer of development rights from one geographic area to another within a region. For example, a local government may adopt a zoning ordinance that assigns a density of 1 dwelling unit per 20 acres (1:20 zoning) to a rural area, and a density of 1 dwelling unit per acre (1:1 zoning) to urban areas. If the local government wished to shift future growth from rural areas to urban areas, it could "downzone," or decrease the density, in the rural areas—for example, from 1:20 zoning to 1:50 zoning—and "upzone," or increase the density, in the urban areas (for example, from 1:1 zoning to 2:1 zoning).

Under a TDR framework, the private market drives the shift in density, once the local government adopts an ordinance allowing urban developers to "purchase" development rights from rural landowners. Technically, the urban developer is paying the rural landowner to place a permanent conservation easement on his or her property, in exchange for the ability to develop at higher densities in the urban area. The amount paid is governed by the free market, but generally should reflect the difference between the value of the rural property with development rights and without them. In this way, the urban developer can secure greater densities in urban markets, while the rural landowner can continue to use his or her property for traditional rural uses and receive payment for development rights without actually developing the property. The TDR program in Montgomery County, Maryland, viewed as one of the most successful in the United States, has preserved nearly 50,000 acres of land through a market-based TDR program.

a. Nonessential housing regulatory requirements may include requirements like minimum lot size, setbacks, open space, landscaping, impervious surfaces, and parking.

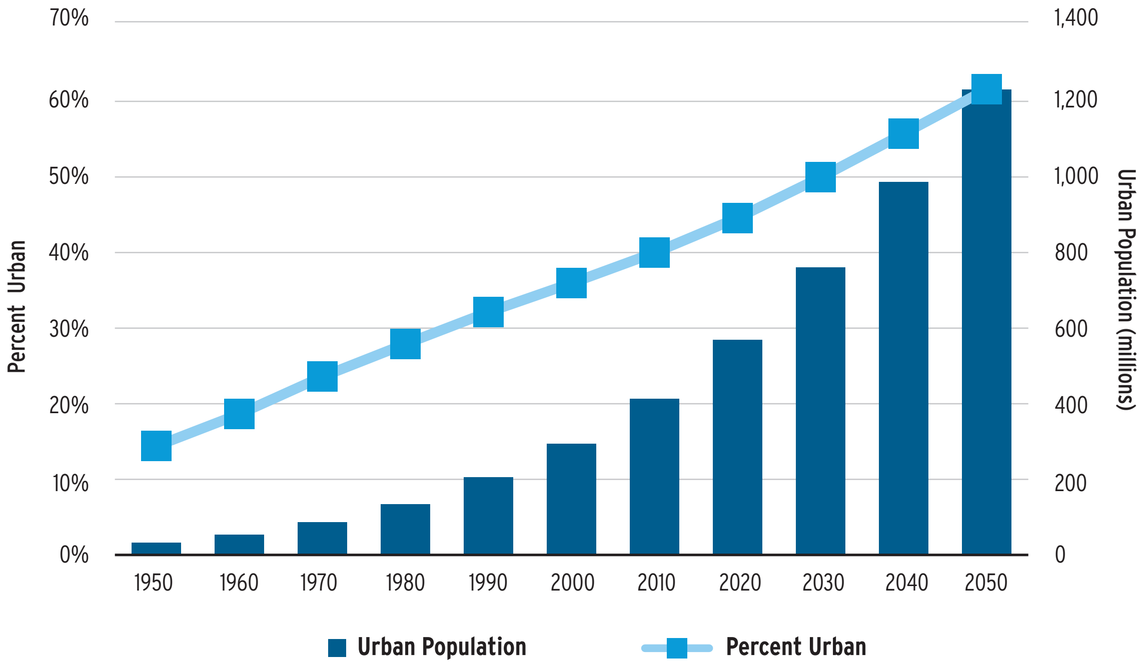


FIG. 7
African Urbanization Trend (1950–2050)

Source: Adapted from UNDESA (2009).

the spontaneous growth that happens outside the administrative boundary. This leads to an actual growth of the metropolitan area that is outside the control or the supervision of specific urban authorities. Only later, when the pressure for infrastructure services arises, is the city administration forced to deal with the massive growth that has happened outside its jurisdiction. In many cases, this growth involves low-income residents who have little capacity to pay for infrastructure, which leads to the spread of slums.

Rapid Urbanization in Africa: Sprawl or Leapfrog?

The dangers and opportunities of rapid urbanization are nowhere more apparent than in Africa, the fastest-urbanizing continent. African cities have been expanding with little coordination, and their situation illustrates the need to manage the urban form through land policy, transportation planning, and service provision.

Although only 40 percent of Africans currently live in urban areas, over the next two decades Africa's urban population is projected to increase at an average annual rate of 3.1 percent, compared to the world's average annual growth rate of 1.7 percent. The driving forces include "push" and "pull" factors of rural-urban migration, natural increase, and reclassification of formerly rural areas as urban (Kessides 2006; UN-Habitat 2008).

By 2030, nearly 350 million new urban dwellers will reside in African cities, as indicated in Figure 7. This will result in unprecedented needs for infrastructure and investment. At the same time, African cities account for over 50 percent of the continent's total GDP, and the rapid growth of cities could allow countries to harness the benefits of urbanization, fueling economic growth and sustainable development.

African countries are at various levels of urbanization, and the urban transition will continue to proceed differently. There will be much slower urbanization in coming years in countries like South Africa (which is already more than 60 percent urbanized) than in East African countries like Tanzania and Kenya (less than 30 percent urban, with average annual urban growth greater than 4 percent between 2000 and 2030).

Urbanization inevitably results in transformations of urban form. Projections indicate that the built-up area of cities in developing countries will triple between 2000 and 2030, while doubling their populations within the same period. As cities' built-up areas grow their density usually declines, as can be observed in Addis Ababa and Nairobi, which are both among Africa's 15 most populous cities. During the last decade, Nairobi and Addis Ababa experienced average annual density declines of about 4 and 2.2 percent, respectively, while their built-up areas increased by 7.1 and 6.3 percent per annum, respectively. Johannesburg, in contrast, displayed a different pattern; its built-up area increased by only 2.1 percent and urban density rose by 1.4 percent per annum between 2000 and 2009.

If similar density changes are experienced in the next 20 years, the cities' forms would be drastically altered, as shown in Figure 8. Although sustained increases in sprawl over a two-decade period are unlikely in the face of other regulating factors, even an annual density decline of 1 percent would increase African urban cover from 1.5 percent of total arable land in 2000 to about 5.6 percent by 2030. This has implications for food security and water management issues, both of which are already a concern for the continent.

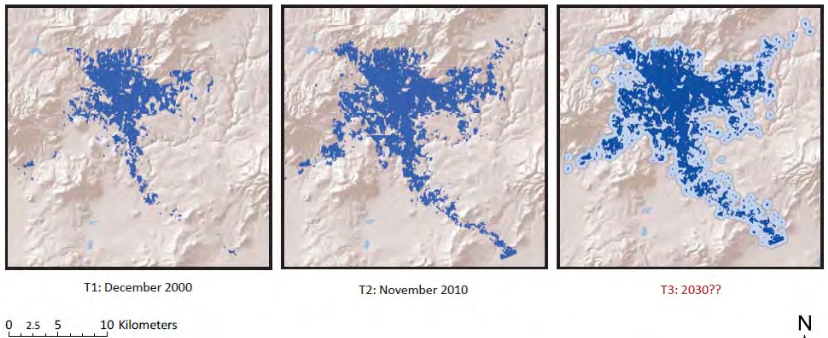
Provision of urban infrastructure and services has not kept pace with urbanization in most African cities. As their populations increase and people become more affluent, the cities are faced with daunting challenges in managing transportation, water and wastewater, solid waste, and energy, with demand far outstripping supply. In addition, uncoordinated growth of cities over the past few years has dispersed their populations, with more people living in the urban peripheries and thereby increasing the cost of infrastructure and service provision. Equal access to infrastructure and basic services is an issue requiring urgent intervention in African cities.

On the other hand, African cities have a unique opportunity to harness the benefits of urbanization. As discussed in Chapter 1, in cities where rapid growth is occurring and many investment decisions on infrastructure and land-use development are currently taking place, making the right decisions will influence the form that the cities adopt. Going forward, urban planning should promote settlement patterns that capitalize on agglomeration economies derived from lower per-head costs of infrastructure networks, high reliance on public and non-motorized transport, and more efficiently planned cities (Glaeser 2011 and Kenworthy 2006). At present, public transport represents only a small fraction of the amount invested in road infrastructure and maintenance in most African cities (UITP 2010). By promoting low-carbon public transport, African cities could "leapfrog" past unsustainable transport development stages experienced by other cities.

The time is now for African cities to act if they are to move toward sustainable urban development. This should be viewed as a win-win situation, where the cities achieve their development agendas while reaping environmental and social co-benefits.

FIG. 8
Spatial Growth of Three African Cities

Addis Abba, Ethiopia

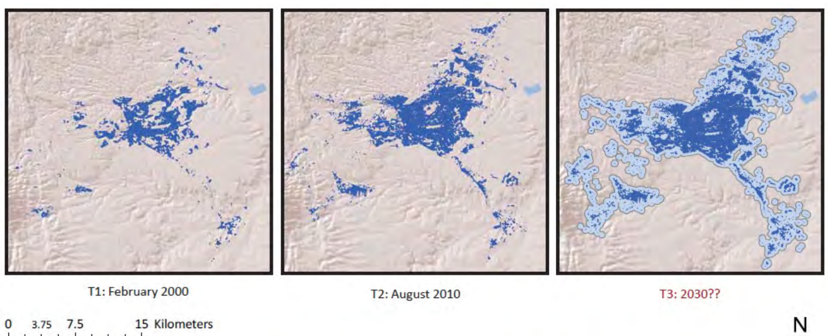


Measure	T_1	T_2	T_3	Annual Change (%) T_1-T_2	Annual Change (%) T_2-T_3
Population	2,376,189	2,929,626	5,832,319	2.12	4.0
Built-Up Area (sq km)	121.75	224.51	741.60	6.31	6.0
Average Density (persons/sq km)	19,517	13,049	7,864.47	-3.95	-3.0
Built-Up Area per person (sq m)	51.24	76.63	127.15	4.11	3.0

N

Key
Built-Up Area
Projected Built-Up Area 2030

Nairobi, Kenya

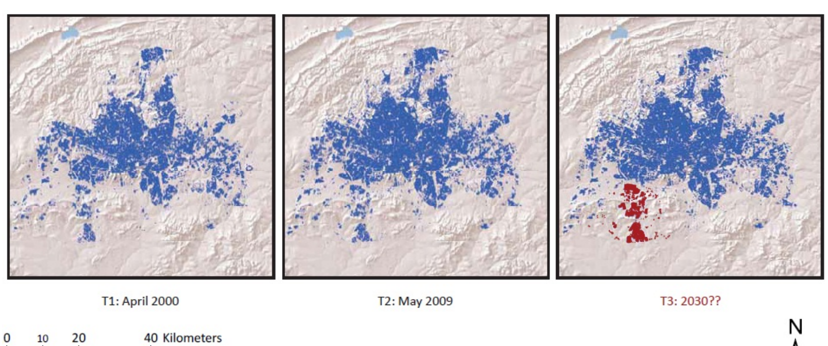


Measure	T_1	T_2	T_3	Annual Change (%) T_1-T_2	Annual Change (%) T_2-T_3
Population	2,230,079	3,523,349	7,610,845	4.68	3.90
Built-Up Area (sq km)	94.33	186.50	603.44	7.05	6.04
Average Density (persons/sq km)	23,641	18,892	12,612.45	-2.22	-2.00
Built-Up Area per person (sq m)	42.30	52.93	79.29	2.27	2.04

N

Key
Built-Up Area
Projected Built-Up Area 2030

Johannesburg, South Africa



Measure	T_1	T_2	T_3	Annual Change (%) T_1-T_2	Annual Change (%) T_2-T_3
Population	2,732,026	3,669,725	4,342,135	3.33	0.84
Built-Up Area (sq km)	160.80	194.45	186.70	2.13	-0.21
Average Density (persons/sq km)	16,990	18,872	23,257.70	1.37	1.0
Built-Up Area per person (sq m)	58.86	52.99	50.0	-1.16	-1.04

N

Key
Built-Up Area
Projected loss in inhabited built-up area, assuming population density increase

Source: Maps created by Henry Jewell (World Bank, Urban Development and Resilience Unit), and Katie McWilliams and Alex Stoicof (World Bank, Sustainable Development Network Information Solutions).

Energy

Cities are the major global energy users (IEA 2008) and the major actors to improve society's energy efficiency while simultaneously decreasing the associated carbon emissions. Many cities, especially in the OECD, have already taken action in this area with policies that increase energy efficiency and promote cleaner energy sources. Worldwide, of the 73 cities that participated in voluntary reporting through the Carbon Disclosure Project in 2012, almost half (48 percent) have a renewable energy target (CDP 2012).

Local strategies can focus on improving energy conservation, increasing the use of renewable energy, improving the efficiency of fossil-based power-generation facilities, transitioning to less carbon-intensive fuels (for example, from coal to natural gas), and employing carbon capture and storage technology. The use of these strategies depends on the institutional capacity of the city, the local resource base and the "willingness of the constituents to bear the price impacts of these policies" (OECD 2011b).

The OECD report *Towards Green Growth* (OECD 2011b) describes some of the systems cities are developing to produce renewable power locally. Some cities have invested heavily in clean heat production, in wind turbines that are typically placed outside city boundaries, and in photovoltaic systems located on buildings or in dedicated open areas. Among the innovators:

- Cities such as Toronto and Amsterdam use lake-water air conditioning and seawater heating.
- Copenhagen's district heating system, which captures waste heat from power generation that is normally released into the sea as hot water, has helped reduce emissions and has taken $1,907 off the average household bill each year. Copenhagen also produces energy from much of its waste, sending a mere 3 percent to landfills (C40 2010a).
- In Freiburg, Germany, photovoltaic panels cover 13,000 square meters (139,931 square feet) of the city's building surfaces, including the main railway station.
- San Francisco operates the largest city-owned solar power system in the United States (C40 2010b).
- The London Array offshore wind-turbine system is due to produce 1,000 megawatts, or enough to power 750,000 homes.
- In 2009, Venice opened the first 16-megawatt hydrogen-fuelled power station, serving 20,000 households.

Cities that are not energy producers, on the other hand, can adopt regulations that promote connection with renewable energy sources and the supply of clean energy to the city grid. Cities are also testing alternative models to the traditional central station grid model. There are experiments with on-site photovoltaics and wind power, and with "smart grid" technologies that monitor the electricity consumed by each household and provide data to inform energy management (see the "Smart Cities" section below). A combination of energy management systems, small-scale distributed energy sources such as solar panels on buildings or mini-wind turbines in the city, and energy storage resources could help to integrate all energy consumption sectors (Figure 9) and optimize the city's energy efficiency. Ideally, cities will be able to develop partial energy self-reliance by means of distributed modes of energy generation, using wind turbines, geothermal energy, solar power, biomass, and other resources.

Until renewables become more commercially competitive, however, saving energy through

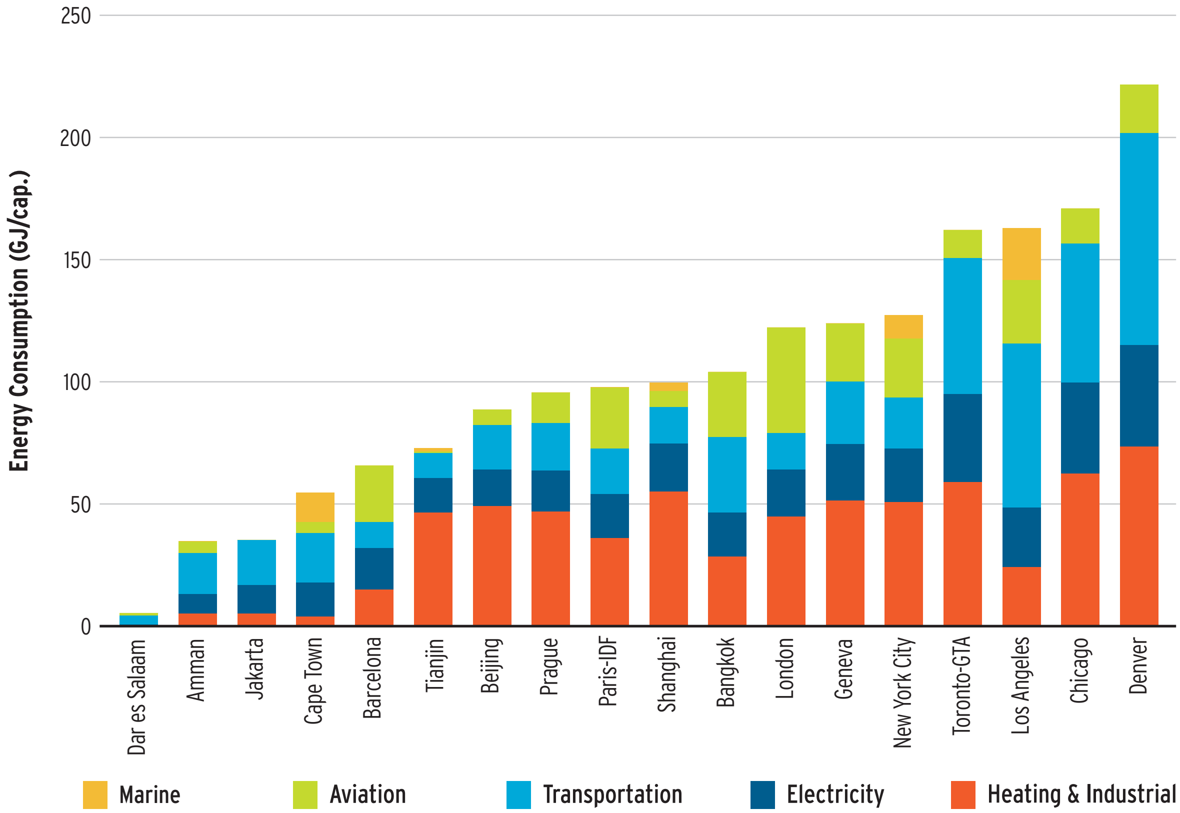
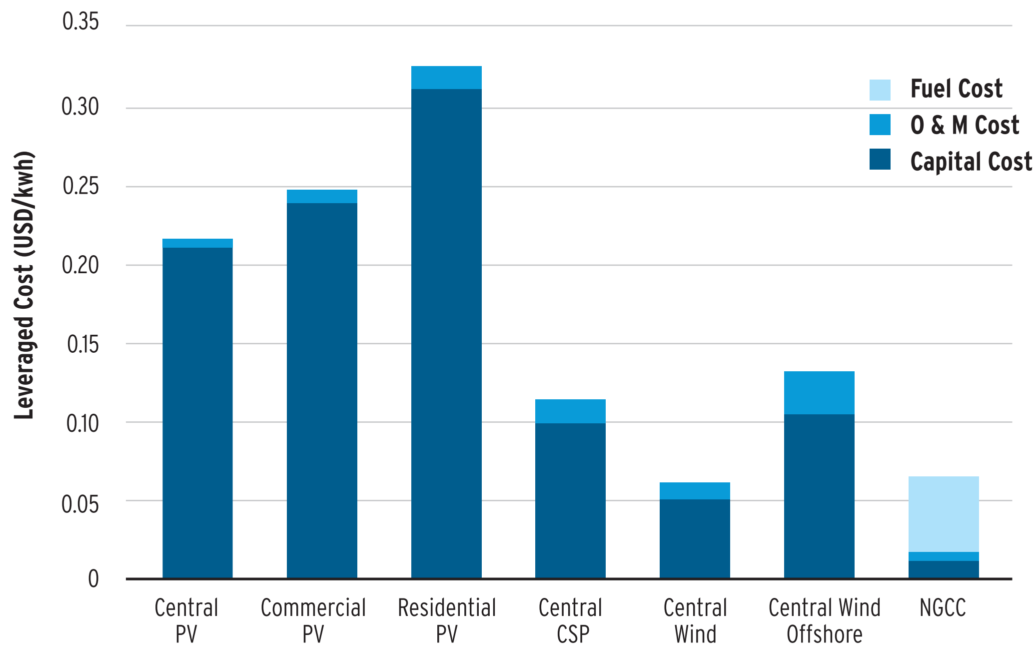


FIG. 9
Energy Consumption Sectors Across a Sample of Cities

Source: Adapted from Kennedy 2011

Photo: Francis Dobbs/World Bank

FIG. 10
Costs of Renewable Energy



Source: Adapted from OECD (2011b).

efficiency measures remains the most cost-effective short-term strategy. While the renewable energy industry has reached a considerable size in developed countries—in 2003, there were approximately 1 million renewable energy jobs worldwide—and costs have dropped substantially, most renewable energy sources are yet not price-competitive with conventional sources (UNEP and New Energy Finance 2010). In addition, distributed generation is more expensive than centralized generation, and residential solar photovoltaics are more expensive than commercial solar photovoltaics (Figure 10). Empirical evidence from California suggests that at \$0.027–\$0.034 per kilowatt-hour, the average cost of energy efficiency is significantly lower than the cost of renewable energy (OECD 2011b).

Nevertheless, investments in renewable energy are needed today to reap benefits over the medium to long term, and cities have a role to play here as well. Feed-in tariffs can be particularly useful to promote supply. With this system, producers of renewable energy contribute solar electricity into the public grid and receive a premium tariff per generated kilowatt-hour, which reflects the benefits of renewable electricity compared to electricity generated from fossil fuels. Feed-in tariffs have helped attract investment for renewable energy in Europe and in a number of United States cities such as Gainesville, Florida and Los Angeles (OECD 2011b). Other strategies that can be highly attractive for renewable energy project developers include direct purchasing of renewable electricity and renewable equipment, soft loans, and guarantees provided by city or regional governments.

Smart Cities

The phrase "smart city" has been applied to everything from distributed power generation to high-tech traffic management, but it is particularly associated with programs that help cities improve their resource-efficiency using information and communications technology (ICT) and technological infrastructure. A broadband digital infrastructure can connect people to each other, people to city systems, and city systems to other city systems. Smart grids and similar technologies track and respond to data from energy, transportation, and ICT infrastructures, allowing integrated management of these sectors. Studies have shown that for a city of 50,000 inhabitants, within 10 years smart city infrastructure could bring significant savings, and consumption of fuel and heat would decline by half, as would carbon dioxide emissions. Electricity consumption would fall by 31 percent.[7]

One of the specific goals of smart grid ICT platforms is real-time monitoring, control, and optimization of distributed energy resources. Increasingly, smart grids and their household counterparts, smart meters and smart homes (Box 18), will allow energy systems to be managed in real time while providing more information to end-users, thus changing behavior and reducing energy demand. Not only households but operators of large buildings, train stations, power plants, and other infrastructure will be able to directly manage their energy consumption and carbon emissions. Eco-districts or clusters of buildings with a networked infrastructure coordinated through ICT platforms can be used to further increase energy efficiency.

When businesses and residents produce part of their own electricity with small-scale solar panels and small wind turbines, smart technologies allow them to feed their excess production back into the grid, helping the city to reach partial energy self-reliance. These "energy-positive" buildings provide not only distributed energy resources but also flexible demand and storage points (for example, electric cars and stand-alone batteries). Storage technologies can be integrated to ensure continuous energy supply at the city scale, and the smart grid can be designed to optimize energy balances based on real-time load forecasts, weather-based generation forecasts and energy price forecasts. These technologies can typically be used within the perimeter of the city, as well as by regional authorities and regulatory bodies wishing to audit and reduce carbon emissions.

Integrated technologies will help dense cities work efficiently (Zenghelis 2011a). Smart, connected cities will monitor and measure resource flows, predict future behavior and simulate changes in demand as a result of policy actions—all of which will feed infrastructure investment decisions (Hoornweg et al. 2007). The applications go well beyond the energy grid. Smart transport systems

[7]http://suslab.eu/partners/innovationcity-ruhr/

Photo: Julianne Baker Gallegos/World Bank

in Singapore, for example, are used to tackle congestion, establish road user charges, and supply real-time information on traffic problems.[8]

The spread of social media (discussed further in Chapter 6) could add another dimension to smart cities, providing new mechanisms for society-wide planning and collective action. For instance, as citizens and cities become more interconnected, governments can begin to replace blunt regulations with highly personalized incentives and instructions. These could be tailored in real-time to coordinate the actions of individuals toward goals like peak load management in the energy sector. Experiments by Cisco in Amsterdam, IBM in Dubuque, Iowa (see Box 19), and others have shown that simply making citizens aware of their individual energy efficiency relative to that of their neighbors can encourage a virtuous race to the top.

The signs are encouraging: smart city initiatives are underway in many urban centers. Cities are already beginning to link solutions to policy goals and initiatives, assessing the value of both household-level smart meters and city-level smart grids. For example, San Diego's benefits from a planned smart grid implementation were estimated to be $2.7 billion over 20 years, with an internal rate of return up to 75 percent and payback period of 3.5 years. Table 3 shows ongoing technology-enabled initiatives in cities of the C40 network.

[8]Examples of the use of connected information technologies to improve the effectiveness, resilience, and efficiency of cities can be found at http://www.connectedurbandevelopment.org/.

BOX 18

Case Study: Smart Homes in Stratford, Ontario

In Stratford, Ontario, the smart home that controls domestic appliances from a single interface—in this case, a tablet—is becoming a reality.

Stratford, a city of 32,000, has begun a series of pilot projects that leverage its municipal Wi-Fi network. One of the most recent initiatives is a joint venture between the city, Toshiba's international lighting division, smart home integration company anyCOMM, and Research In Motion (RIM), maker of the PlayBook tablet. The project will see 30 Stratford homes and businesses fitted with Wi-Fi enabled LED light bulb prototypes from Toshiba, wirelessly networked and controlled via RIM's PlayBook touchscreen loaded with anyCOMM home-automation software.

The technology will start with on/off and dimming commands for individual bulbs and is expected to evolve features such as smart wall plugs, heating and cooling controls, and home security. Once the system is proven, the larger plan is to deploy the LEDs and tablets across the city's 20,000 homes and businesses.

These in-home systems will be integrated with Stratford's citywide wireless smart meter system, allowing customers to control their energy costs, usage, timing, and conservation. They will be able to access their home controls over the Internet. For the technology partners, this provides a 20,000-site living lab to develop and refine the systems.

The tablet program follows investments in a hybrid Internet infrastructure analogous to other utility and infrastructure networks such as electricity, water, natural gas, and transportation. When the Province of Ontario's energy board mandated electrical utilities to switch to smart meters that would provide consumers with their hourly usage data, Stratford opted for a Wi-Fi mesh canopy over Rhyzome's 70-kilometer loop of optical fiber woven through the city. As a result of this meter data backhaul system, there is contiguous, ubiquitous high-speed Internet access across the entire operating area.

An integrated system also offers social engagement and two-way communications with the city, giving households access to online services and city information—from school bus cancellations to emergency preparedness and disaster response. Recognizing this vision for economic and social infrastructure, the New York-based think tank Intelligent Community Forum designated Stratford as one of the top seven "intelligent communities" worldwide in 2011 and 2012, ranking it among cities such as New York, Seoul, Stockholm, and Taipei.

IBM's Smart City Projects

BOX 19

IBM is a member of the Sustainable Cities Partnership and has been active in research and development of smart city technology, partnering with cities across three continents:

Portland, Oregon: Understanding Connections between City Systems

Today most cities are managed in silos, but this approach does not mirror how cities function in reality. Through a partnership with the City of Portland, IBM has developed an approach to city planning that looks at a city all at once and over time. IBM System Dynamics for Smarter Cities is a systems-thinking tool that helps city leaders learn how their city functions as an interconnected "system of systems" by exploring interactive visual maps and simulating macro-level policy changes. By enabling them to visualize how city systems work together, the simulation model helps city leaders analyze policy decisions and their impact on citizens.

The simulation model: (a) examines the relationships that exist among a city's core systems, such as the economy, housing, education, public safety, transportation, health care, government services, and utilities; (b) allows city planners to see how city systems interact with and affect each other in order to improve long-range city planning and help them become systems thinkers; and (c) enables municipal officials to create countless "what if" scenarios. Portland is using the model to help create a new 25-year strategic plan for the city.

Rio de Janeiro: Improving Emergency Response

The City of Rio de Janeiro and IBM are collaborating on a city operations center designed to improve emergency response coordination, manage increased traffic flows, and improve city services as the city prepares for hosting the 2014 World Cup and the 2016 Olympics. Following a series of floods and mudslides in April 2010, the Rio Operations Center was initially designed to improve city safety and responsiveness to incidents. In 2011, IBM and the local government extended their collaboration with the announcement of an emergency alert system that will notify city officials and emergency personnel when changes occur in the flood and landslide forecast for the city. In contrast to a previous system in which notifications were manually relayed, the new alert system is expected to drastically reduce the reaction times to emergency situations by using instantaneous mobile communications, including automated email notifications and instant messaging, to reach emergency personnel and citizens.

Currently, the city operations center integrates and interconnects information from more than 30 government departments to one centralized command center, helping local government officials gather data across city operations to monitor and respond to problems more quickly, and to predict potential problems that might emerge in order to minimize impact. Over time, the goal is to expand this center to also cover transportation, public works, and utilities.

Dubuque, Iowa: Promoting Sustainability, Economic Growth and City Brand

In 2009, The City of Dubuque and IBM came together to form Smarter Sustainable Dubuque (SSD), a public-private partnership with the aim of leveraging smart technologies to improve sustainability and economic growth and development in Dubuque, Iowa. Together, IBM and the local government hope to make Dubuque one of the first smarter sustainable cities in North America, and to develop new smart technologies and a sustainability model that can be replicated globally in communities of 200,000 and smaller—where over 40 percent of the population of the United States resides. Reflected in the design of SSD is the local government's belief that the key to long-term sustainability is to give consumers and businesses the information that they need to make informed decisions about how they consume resources like electricity, water, natural gas, and oil.

The first project, the Smarter Water Pilot, enabled households to view their water usage on an hourly basis, take advantage of water conservation tips, compare their water usage performance against other households, and be alerted if leaks were detected. After the 3-month pilot, participants decreased their water use by 6.6 percent, and leak detection and response was increased eight-fold. Other projects under SSD include Smarter Electricity, Smarter Natural Gas, and Smarter Travel Pilots.

Stockholm: Improving Traffic Flows and Decreasing Pollution

Like many other cities in the world, Stockholm is battling the problem of too many cars on too few roads—with over half a million cars traveling into the city every weekday. By 2005, average commute times were up by 18 percent from the year before. To combat this problem, the Swedish National Road Administration and the Stockholm City Council announced in early 2006 a trial congestion tax, similar to the road-charging systems in London, Oslo, and Singapore. The goal was not only to reduce congestion, but to also encourage ancillary benefits, such as improving public transport and alleviating environmental damage. The government's plan is to devote revenue from the tax to the completion of a ring road around the city. The trial period ran from January to July 2006, and the tax was reinstated in 2007 by the then newly elected city government.

As a related follow-up project, IBM is collaborating with KTH Royal Institute of Technology in Sweden to provide Stockholm residents and officials a smarter way to manage and use transportation. Researchers at KTH Royal Institute of Technology are using IBM's streaming analytics technology to gather real-time information from the GPS devices on nearly 1,500 taxi cabs in the city. This will be expanded to gather data from delivery trucks, traffic sensors, transit systems, pollution monitors, and weather information. The data, processed by IBM's InfoSphere Streams software, gives city officials and residents real-time information on traffic flow, travel times, and the best commuting options.

Additional details and media coverage can be found at:

http://www.ibm.com/podcasts/howitworks/040207/images/HIW_04022007.pdf

http://www-03.ibm.com/press/us/en/pressrelease/29903.wss

http://www-935.ibm.com/services/us/gbs/bus/html/gbs-sra-video-landing.html

TABLE 3
Technology-Based Initiatives in C40 cities

Sector	Actions	Description	Implemented	Authorised or Awaiting Authorisation
Energy	Smart grid	Sensors and instrumentation to improve distribution network efficiency, in conjunction with smart metering, helps match energy demand and supply	6	11
	Building energy management system	Occupants can automate the energy-consuming systems in buildings	13	3
	Smart building sensors and controls	Building sensors and controls allow for better use of buildings, or prediction of faults	12	9
	Smart energy metering	Automated meter reading enables utility and occupants to access information digitally	17	14
	Outdoor lighting smart controls	Dimming and other controls enable greater energy efficiency	3	3
Transport	Smart transport cards	Ideally smart cards link multiple forms of transport and make it more convenient to use and for transport authorities to understand mobility patterns	18	10
	Car clubs	Users can hire or share vehicles easily, and will ideally not buy a car, but instead simply use one when it is convenient	6	1
	Cycle hire programs/ sharing programs	Users can hire bicycles instead of driving	10	7
	Electric buses	Buses that are more efficient and ideally run on renewable power	10	3
	Electric trains	Trains that are more efficient and ideally run on renewable power	8	3
	Electric vehicles	Vehicles that can become mobile storage for energy, helping to balance peak demand	14	14
	Real time information for logistics	Telematics and communications with drivers to optimise routes	7	0
	Real tme transport information	Provides the basis for mobile applications for journey planning	18	10
	Real time transport displays	Provides visibility to users and encourages uptake of public transportation	12	7
Water	Smart water metering	Monitors and helps water managers reduce waste in the system, saving 10–15% per household	12	3
Total			**29**	**28**

Source: CDP 2011.

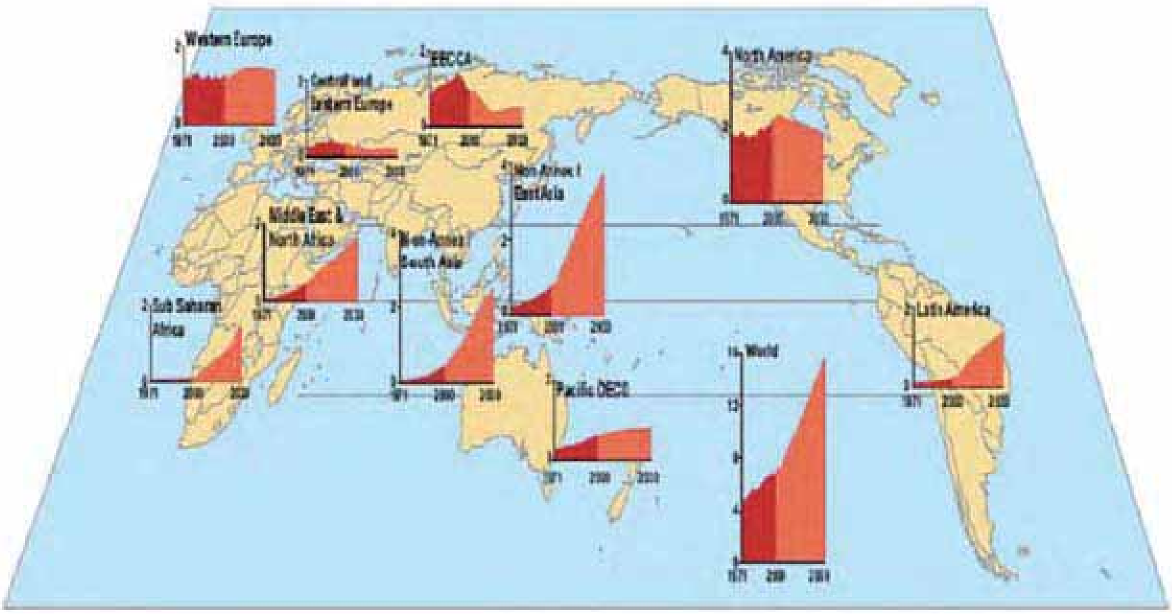
Buildings

Buildings account for approximately 40 percent of the world's energy use (UNEP 2009a) and building-related greenhouse gas emissions have been estimated at 8.6 million metric tons of carbon dioxide equivalent in 2004 (Levine et al. 2007). Assuming that emissions will continue growing at a high 2.5 percent per year, that figure could reach 15.6 billion metric tons of carbon dioxide equivalent by 2030 (UNEP 2009a).

Historically, the majority of emissions from buildings have been generated in North America, Europe, and Central Asia, but the total emissions from buildings in developing countries are expected to surpass these regions by 2030 (Figure 11). The long lifetime of buildings (50 to 100 years) locks in their design and technical characteristics for decades. But in this growth phase, new buildings also provide opportunities to reduce energy consumption through the careful selection of construction materials, building design, equipment, and appliances, and during building operation.

FIG. 11
Carbon Dioxide Emissions from Buildings

IPCC High-Growth Scenario



Source: Reprinted from UNEP (2009a); data from Levine et al. (2007).

Note: Shown are carbon dioxide emissions from buildings (including through the use of electricity). Dark red: historic emissions. Light red: projections 2001–2030. Data for 2000–2010 are adjusted to actual 2000 carbon dioxide emissions. EECCA: Countries of Eastern Europe, the Caucasus and Central Asia.

Photo: Curt Carnemark/World Bank

Indeed, the building sector has greater potential than any other sector for significantly reducing greenhouse gas emissions (Figure 12). This means that with commercially available technologies, energy consumption in both new and existing buildings can be cut by an estimated 30 to 80 percent with a potential net profit during the building lifespan.[9] The potential for successful business in this sector cannot be underestimated.

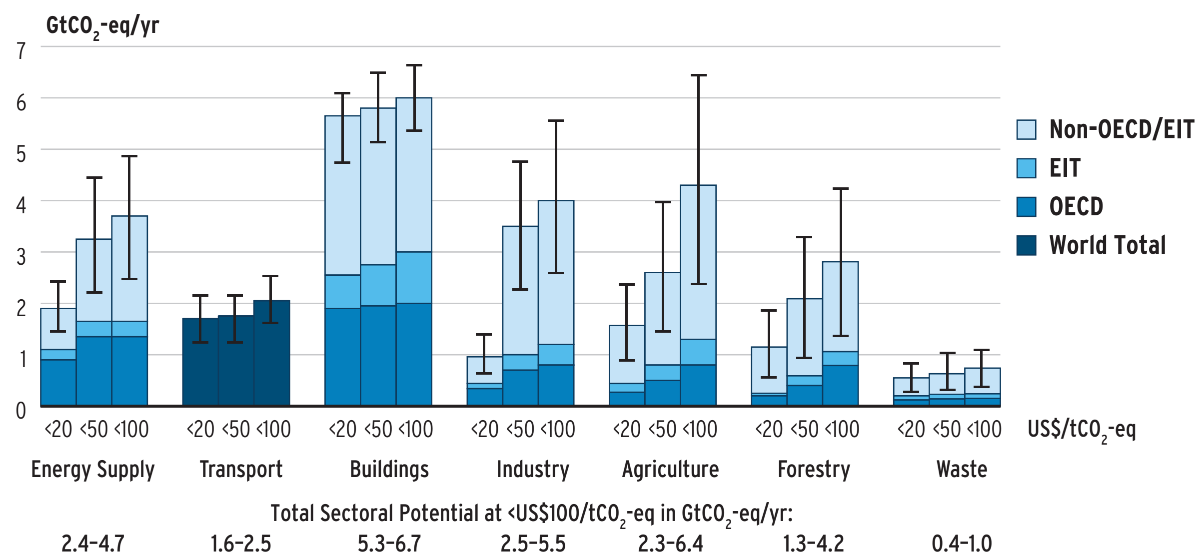
Many countries and cities have tried to implement policies to reduce the greenhouse gas emissions of buildings, but there are several bottlenecks. First, the building sector is highly fragmented, from design through to the decommissioning phase. No single policy framework would be able to affect all these phases. In addition, as discussed in Chapter 2, the economic incentives for resource-efficiency are poorly designed—in particular, split incentives between building owners and tenants may prevent action—and the costs and benefits of efficient solutions are not widely known or benchmarked. Given the technical nature of green building, the engineering and design professions have an opportunity to make available standardized technical notes that could be distributed among the builders and developers in cities around the world.

Despite the challenges, the record of countries and cities in implementing legislation and changing behavior is encouraging (Table 4). Some typical initiatives include:

Building codes: Most developed countries have codes for new buildings that are performance-based—for example, they set a maximum limit for the level of heat transfer through the building and require that all the equipment meet certain energy standards. The European Union has harmonized the standards for energy performance and certification in buildings. (European Commission 2008).

[9]Study and best practices in the United States show that just adjusting building operational practices can reduce energy use between 20 and 40 percent without requiring equipment upgrades or substantial retrofits. See: http://esl.tamu.edu/

FIG. 12. Estimated Economic Mitigation Potential



Source: Adapted from Metz et al. (2007).

Note: Graph shows estimated economic mitigation potential using technologies and practices expected to be available in 2030, organized by sector and region.

Mandatory building energy audits: In the United States, savings identified after energy auditing can average 38 percent in cooking, 62 percent in heating, and 25 percent overall energy savings.

Appliance standards are in place in some countries for energy-using products such as lighting, heating and cooking equipment, and personal computers. The Top Runner program in Japan resulted in energy-efficiency improvement of more than 50 percent (Geller et al. 2006). Standards are cost effective because they reduce transaction costs for consumers and producers.

Encouraging off-grid applications of renewable energy technologies in buildings: For example, solar water heaters have been mandatory for new buildings in Spain since 2005 and Australia since 2006. Baden-Wurttemberg in Germany has enacted legislation imposing rules on new buildings regarding how much of their energy should come from renewable sources. Germany, Ireland, Japan, Luxemburg, and South Africa all use national subsidies to encourage public structures to use renewable energy.

Disseminating renewable energy appliances: In developing countries, particularly those with low electrification rates, there has been great progress. A major Dutch and German project initiated in 2004 has provided 5 million people with access to improved cook stoves and electricity. Many projects financed by the World Bank and regional development banks have also had a clear impact on the use of renewable fuels.

Zero-carbon buildings where energy provided by on-site renewable sources is equal to the energy used by the building. Zero-energy buildings are connected to the main electricity grid but have zero net consumption because they produce more energy in the summer and consume more in the winter. Interesting projects have been piloted, notably a Worldwide Federation for Nature (WFN) zero-energy housing project in the Netherlands and the Malaysia Energy Center (Pusar Tenaga Malaysia) headquarters in Kuala Lumpur. The town of Pedra Branca, Brazil, has 2,000 residents aiming to become a zero-carbon community. In Germany, passive building technologies are spreading rapidly, while in France, the Grenelle de l'Environment in France recommended that all new housing be passive or energy-positive by 2020 (USGBC 2011).

Photo: ©Bigstock

Rapid-deployment neighborhoods: From 2000 to 2010, an estimated 6 million people per year were added to the world's urban slum population, out of a total 58 million new urban dwellers per year in the developing world (UN-Habitat 2010b). Suitable housing must be provided rapidly to prevent slum formation. This can be accomplished by off-site, factory-based, parallel assembly of building subsystems (structural, floor, and façade). This is not only a faster and more efficient construction method, it also reduces construction waste and vehicle travel to and from the building site, as deliveries are made only when components are completed and fewer workers are required on site during assembly. Pilots of the rapid-deployment neighborhood system have been carried out in Bangladesh, India, Nigeria, and Pakistan.

TABLE 4
Examples of Policies to Improve Building Energy Efficiency

Program Categories	Program Examples
Policies and Targets Energy-saving goals; tracking and reporting progress government organisation (lead responsibility for energy savings, interagency committees etc.) Budget policies (e.g. life-cycle costing, separate budget line for energy, energy cost saving shared with agencies	Agentina (reporting) Dominican Republic (goals) Ecuador (goals) Mexico (saving goals and reporting requirements) Philippines (GEMP goals)
Energy-Saving Capital Projects Energy audits Retrofit projects: lighting, HVAC, building envelope, controls Financing: third-party (ESCO) funding, loan funds, leasing Efficiency standards/guidelines for new buildings Design assistance, software tools, architect training New technology demonstrations, showcase facilities Public services, efficient systems and equipment (water supply and treatment, street lighting, LED traffic signals)	Brazil (low-interest loans to retrofit public buildings) Colombia and Argentina (street lighting) Mexico (Web-based lighting audits, "100 Public Buildings" and APF) Russian Federation (pilot audits and retrofits)
Facilities Operation and Maintenance Building system commissioning: pre-occupancy + continuous energy metering/monitoring, benchmarking, operator feedback Facility manager training and certification Operator incentives and recognition (awards) Employee information and outreach campaigns O&M for government vehicles; promote ridesharing and transit	Dominican Republic Mexico (building O&M, operator training, "Ports of Attention" for outreach + technical assistance) Thailand (mandatory measures in public buildings)
Purchasing Energy-efficient Products Speciy efficient building equipment, office equipment, motors, lighting, appliances, etc. Efficient and alternative fuel vehicles for government fleets Green power purchasing	Republic of Korea Philippines (GEMP)

Source: Adapted from Hallegate et al. 2011

Public policies for green buildings generally include three options: revising zoning codes, incentivizing developers, and making public access to finance conditional on sustainability criteria. The recent report *Building the Green Economy from the Ground Up* (USGBC and Green Building Council Brasil 2011) suggests four pillars of intervention: fostering green communities and neighborhoods, achieving sustainable and affordable housing, building green schools, and pursuing resilience as part of the sustainable built environment. At the community or neighborhood level, many tools exist to help assess and increase energy-efficiency—for example, the LEED for Neighborhood Design rating system from the U.S. Green Building Council (USGBC), and ICLEI's STAR Community Index.[10]

In the building industry, there is consensus on the attractive market potential for efficient new buildings and retrofitting old buildings (Boxes 20 and 21), and a growing number of building owners are combating rising energy prices by pursuing energy efficiency. The Fifth Annual Global Energy Efficiency Survey (Johnson Controls, IFMA, and ULI 2011), which polled 4,000 building owners around the world, shows that energy cost savings,

[10] http://www.icleiusa.org/sustainability/star-community-index/

government incentives, and enhanced public image are driving energy efficiency in buildings to new heights. The expected rise of energy costs is especially motivating, as 80 percent of respondents expect double-digit energy price increases over 2012.

The survey indicates that 75 percent of building owners have set energy reduction goals—targeting 12 percent reductions, on average—and nearly 40 percent have achieved at least one green building certification, which is twice as many as the previous year. An additional 32 percent have incorporated green building elements such as lighting, heating, ventilation, air conditioning, and controls improvements, which continue to be the most popular energy efficiency improvements; 77 percent of the North American building owners plan to include green building elements in their facility plans in the next 12 months. Efficiency in buildings remains the top global strategy for reducing greenhouse gas emissions in the United States, Europe, China, and India.

Photo: Shutterstock

BOX 20

The Commercial Building Retrofit Market Potential

From 2010 to 2020:

- The market potential for commercial building retrofits is projected to be $190 billion over the next 10 years, or roughly $19 billion annually.
- Annual energy costs in the existing commercial building stock total $100 billion, or roughly $1.40 per square foot over 72 billion square feet.
- Achievable energy savings at any one building may typically range from 5 percent to 60 percent, depending on building age, type, design, condition, and maintenance.
- Achievable energy savings across the existing commercial building stock is estimated to potentially reach 22 percent.

Source: Johnson Controls. Reprinted from Johnson Controls, IFMA, and ULI (2011).

Embodied Energy and Historic Buildings[11]

Most of the current debate on energy in buildings focuses on "operational energy," the energy needed for building occupancy and use—heating, cooling, and lighting, for example. But buildings are actually associated with two types of energy: embodied and operational. Embodied energy is the energy consumed by all of the processes related to the construction of a building, including the mining and processing of natural resources to manufacture building materials, transport, product delivery, and final assembly at the construction site (see Box 22). More refined analyses consider the energy consumed in all stages of a building's life cycle, including resource extraction, manufacturing of building elements, construction, use, and disposal and decommissioning. Recent studies demonstrate that embodied energy and operational energy contribute to the overall energy balance of a building in almost equal shares and that, combined, they are responsible for about 50 percent of global carbon dioxide emissions. An integrated approach tackling both types of energy use is urgently needed to reduce building-related emissions.

[11] This section has been adapted with permission from Licciardi (2012).

BOX 21

Case Study: Reducing Operational Energy in the Empire State Building

In 2009, sustainability experts joined forces to retrofit the Empire State Building in New York using an innovative design process and state-of-the-art tools. The guiding goal was to use the most cost-effective measures to produce the most energy savings. After comprehensive research, it was found that rather than replacing the windows and purchasing new ones from distant factories, it was more energy efficient and cost effective to upgrade the 6,514 dual-pane existing windows by conserving frames and glass and upgrading them to super-insulating glass units in a dedicated processing space located on-site. As a result, 96 percent of the frames and glass of the Empire State Building were conserved and reused.

The project was completed in October 2010 as one of eight measures in an innovative energy retrofit of the building. The upgraded windows are expected to pay for themselves in three years. The project's impacts include conserving embodied energy of existing windows (made of aluminum and therefore having a very high PER); reducing operational energy use by 38 percent; saving $4.4 million per year in operational energy costs; and saving 105,000 metric tons of carbon dioxide emissions over the next 15 years, equivalent to the annual emissions of 17,500 cars.

Photo: ©istockphoto

Measuring Embodied Energy

While operational energy can be easily determined by measuring what is needed to operate a building, embodied energy is less apparent because it is embedded in the various steps of building construction and material production. Various tools exist, however, to analyze embodied energy, and they are becoming increasingly refined.

Gross energy requirement (GER) is a measure of the true embodied energy of a material, which would ideally include all of the steps from mining to assembly. Research has made significant progress toward assessing GER, and a number of tools have been widely tested to measure the subset of GER known as the process energy requirement (PER).

Process energy requirement (PER) is the energy directly related to the manufacture of building materials. It includes the energy consumed in transporting the raw materials to the factory as well as material production, but not the energy consumed in transporting the final product to the building site and assembling it, which are the remaining components of GER unaccounted for by the PER. In general, PER accounts for 50–80 percent of GER, and PER tables are widely available for a variety of building materials. Both GER and PER are measured in megajoules of energy needed to make a kilogram of product.

The consensus on PER data for a wide range of materials is extremely encouraging, and the data can already be used by stakeholders, designers, and developers to make effective decisions in urban development, especially to advocate conservation and adaptive reuse of existing built assets. As an example, producing 1 kilogram of aluminum requires 170 megajoules, whereas producing 1 kilogram of bricks can require as little as 2 megajoules. In practice, this means that choosing materials with a lower PER dramatically reduces the embodied energy of a building. It also means that by conserving and adaptively reusing existing buildings, the total PER (that is, the cumulative PER of their constituent materials) does not have to be discarded, which substantially reduces greenhouse gas emissions.


Photo: ©Bigstock

BOX 22

The SBTool standard, the U.K. Code for Sustainable Homes, and the LEED Rating System from the USGBC already take embodied energy, along with other factors, into consideration when assessing a building's environmental impact. These standards are very effective tools to promote both energy efficiency and the conservation of embodied energy in existing and historic built assets. For instance, under the LEED system, projects can earn one credit for reusing 75 percent of the core and shell of an existing building.

Life-cycle assessment (LCA) examines impacts during a building's entire life, rather than focusing on one particular stage. Unlike traditional embodied energy calculations, LCA provides an assessment of direct and indirect environmental impacts associated with a building by quantifying energy, material use, and environmental impacts at each stage of the life cycle, including resource extraction, goods manufacturing, construction, use, and disposal and decommissioning. LCA makes an even stronger case for conserving and adaptively reusing historic built assets and is the basis for the distribution of points under the updated LEED standards.

Embodied energy can be saved in two ways: by reducing the energy used to produce and assemble materials in new buildings, and by conserving and adaptively reusing existing buildings. In both cases, international practice has demonstrated that it is most important to focus on long-lived, durable buildings, which store the most energy over time. In fact, the best way to save embodied energy is to make buildings last longer.

In the case of new buildings, a higher embodied energy can be justified only if it contributes to lower operational energy. For example, high thermal mass (associated with high embodied energy) can significantly reduce heating and cooling needs in well-designed and insulated passive solar houses. However, priority should go to conserving embodied energy in existing buildings, considering the variety of options to adapt older structures for changing needs (Box 23). Demolishing existing buildings to construct new ones generates additional greenhouse gas emissions during demolition, debris and waste disposal, production of new materials, and assembly of replacement buildings.

There is a common misperception that historic buildings are energy inefficient, and that the environmental impacts of demolition and new construction are easily outweighed by the energy savings from contemporary, green buildings. In fact, recent research has found that conserving, reusing, and retrofitting existing buildings are often better options. This saves the embodied energy used in the construction of older buildings—and in addition, buildings constructed before the advent of cheap fossil fuels actually operate more efficiently than most late-20th-century buildings, according to a groundbreaking study of the U.S. Energy Information Administration (2006).

The study, which has since been followed by a number of similar investigations worldwide, concluded that contemporary, highly energy-efficient buildings require the same operational energy as historic assets built before the 1920s (Figure 13). This finding is based on a simple analysis of the operational energy needed for similar categories of existing buildings still in use, by year of construction. Only assets built in the second half of the 20th century are energy inefficient—a result of the low cost of energy at the time of their construction.

In contrast, earlier building designers and developers faced very high energy costs, and addressed this in their designs and construction methods. Generally, historic buildings have thick, solid walls with high thermal mass that reduces the amount of operational energy needed for heating and cooling. Moreover, buildings designed before the widespread use of electricity feature windows designed for natural light and ventilation, as well as shaded porches and other details to reduce

BOX 23

Case Study: Reusing Historic Mansions in Qufu and Zoucheng

An innovative project currently under preparation, financed by the World Bank ($50 million) and China ($70 million), will regenerate the two historic cities of Qufu and Zoucheng in Shandong Province. In light of the importance of embodied energy, one project component focuses on the conservation and adaptive reuse of two large historic buildings that are currently underutilized. The Confucius and Mencius mansions are vast former residences that today are mostly abandoned. The buildings will be revitalized to host a number of new productive functions, from knowledge centers to growth poles for sustainable tourism. The physical conservation of the mansions will maximize the use of low-impact traditional techniques and locally available building materials to reduce the additional embodied energy the project will create.

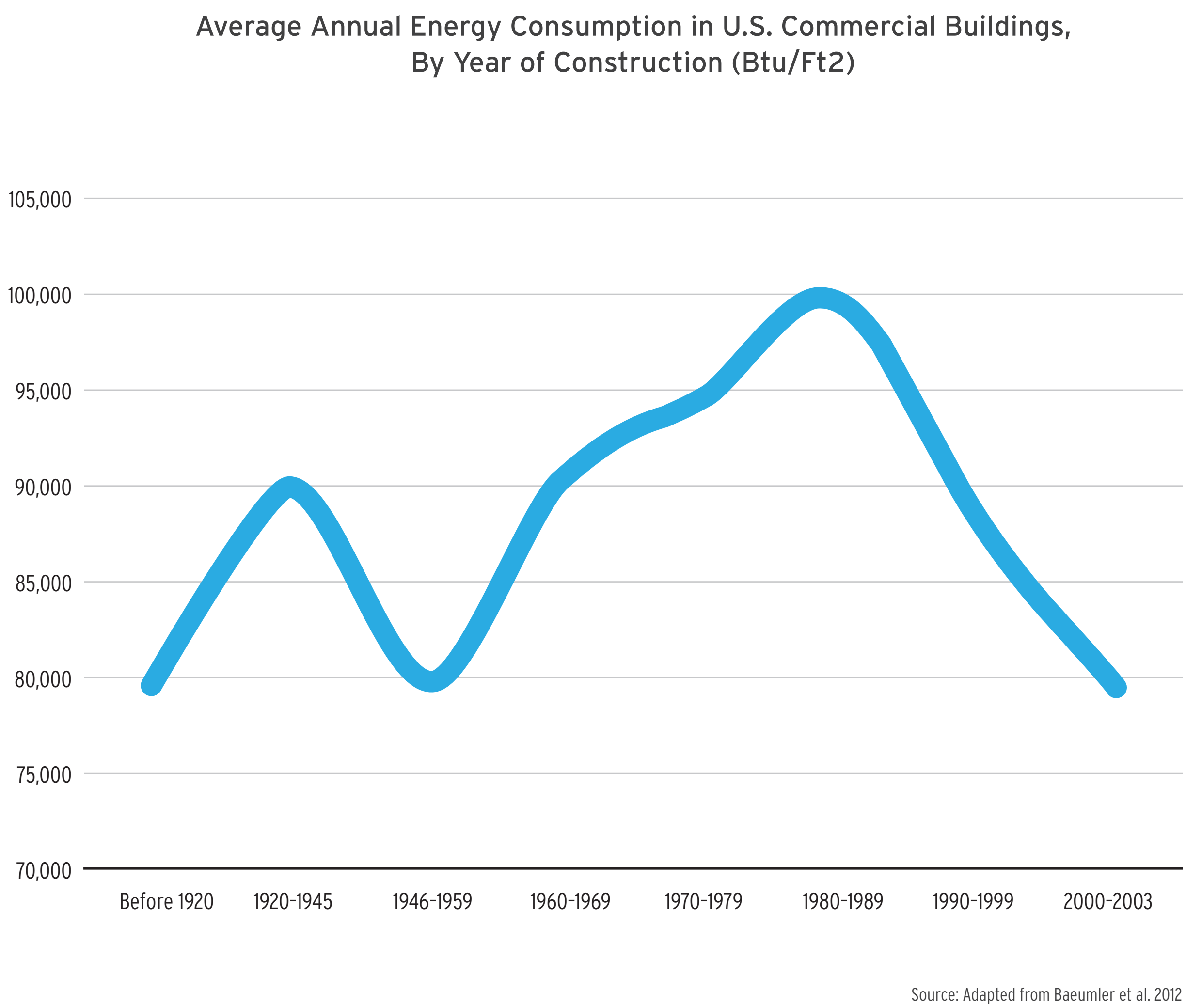


FIG. 13.
Energy Consumption in U.S. Commercial Buildings of Different Ages

solar gain. In the past, designers and developers also paid close attention to location, orientation, and landscaping as methods for maximizing sun exposure during the winter months and minimizing it during warmer months (that is, passive heating and cooling systems).

Historic buildings are also mostly located in densely built areas that were the norm in the era before cars proliferated and urban sprawl became prevalent, and so they gain the benefits of compactness discussed in Chapter 2. District energy systems can be used for power generation, as China has been doing for decades, which also creates substantial carbon savings. Municipal infrastructure requirements for roads, sewers, communication, power, and water are also reduced by high-density developments, which is where most historic buildings are located. Thus, the adaptive reuse and repurposing of historic buildings, together with the provision of appropriate retrofit measures, can contribute to significant energy and resource conservation, as well as cultural heritage preservation.

Transportation

Transport now contributes 13 percent of global greenhouse gas emissions (Metz. et al. 2007), and these emissions are likely to increase exponentially in developing countries, where demand for private transportation is rapidly increasing (Box 24). This demand has to be managed carefully from the outset, because transport sector investments are resource-intensive and very difficult to undo. Once road and rail networks are established and entire communities grow around them, retroactively replanning employment and population centers is an almost impossible undertaking

BOX 24

The Urgent Need for Sustainable Urban Transport

The global vehicle fleet is set to increase from approximately 800 million to between 2 and 3 billion by 2050 if we continue on a businessĐasĐusual path, with most of the growth taking place in developing countries (UNEP 2011). With the middle class in developing countries becoming more affluent and more dependent on private vehicles, cheaper vehicles such as the Tata Nano and Bajaj RE60 becoming available (at a cost of around $2,500), and slow turnover of vehicle stock, both the demand for transport fuels and associated emissions are expected to further increase in the coming years. The lack of progress towards increasing vehicle fuel efficiency and reducing the carbon content of fuel, coupled with the increase in the number of vehicle-miles traveled, is already negating air pollution reductions resulting from the adoption of green transport systems such as bus rapid transit, light rail, and subways. If not contained, the increase in emissions from the transport sector will offset greenhouse gas reductions being made in other sectors. There are three sources of concern:

Transport fuels are large emitters of pollutants. Road transportation vehicles emit harmful substances such as carbon dioxide, carbon monoxide, non-methanous volatile organic compounds, methane, nitrogen oxides, particulate matter, and sulfur dioxide. While gasoline-fueled vehicles account for 80 percent to 90 percent of total volatile organic compounds and carbon monoxide, diesel vehicles are the main source of nitrogen oxides, sulfur dioxide, and particulates (Rodrigue 2013). They account for 66 percent of nitrogen oxides, 70 percent sulfur dioxide, and 90 percent of particulate emissions. In many megacities in Asia, particulate matter already exceeds 300 micrograms per cubic meter, which is above the WHO standard—and levels are rising. Road transport is a major cause of urban smog, which is a mixture of smoke, fog, and chemical fumes.

The current and expected growth in transport fuel demand will cause a tremendous public health burden. Particulate pollution has been found to increase chronic cough in children. Prospective cohort studies conducted by the American Cancer Society found that long-term exposure to particulate matter is associated with respiratory illness in children. Epidemiological and clinical investigations suggest a strong link between particulate pollution and cardiopulmonary morbidity and mortality. According to the Clean Air Task Force (2005), diesel exhaust poses a cancer risk 7.5 times higher than the combined total cancer risk from all other air toxins.

Growing transport fuel demand in developing countries, particularly for diesel, will accelerate global climate change. The transport sector accounts for 13 percent of all greenhouse gas emissions and 23 percent of all energy-related carbon dioxide emissions globally. The troubling aspect of transport-sector emissions is that they are increasing quite rapidly and will continue to do so in the years and decades to come. Carbon dioxide emissions from the transport sector increased by 28 percent between 1990 and 2006. They are expected to rise by another 57 percent in the period 2005–2030, and by 2050 they will be up 120 percent from 2000 levels. Black carbon, along with methane, is one of the major global warming agents after carbon dioxide. Increased use of diesel fuel in the transport sector will lead to further increases in particulate emissions, including black carbon, as vehicles tend to be poorly maintained in developing countries.

(World Bank 2010a). A lower-emission trajectory can be achieved if government-backed alternatives for low-carbon development gain traction.

The discussion on urban transport goes hand in hand with city density and land use. As discussed in Chapter 2, there is empirical evidence that denser cities emit less greenhouse gas, have greater satisfaction and well-being, and provide transportation services at much lower cost than sprawling cities. In many cases, transport mode choice management combined with and land use management has led to cost-efficient use of valuable urban land and infrastructure. Portland, Oregon, has saved $2 billion annually through three decades of coordinated policies to change land use and transport systems. Measures include modest increases in building density, light rail transit schemes, and policies to encourage walking and cycling. Other cities like Copenhagen, Hong Kong, London, New York, Paris, Singapore, Vienna, and Zurich show that it is possible to foster green growth, decoupling economic "goods" from environmental "bads."

There is a wide consensus that the policy package to reduce greenhouse gas emissions from transport should contain three types of policies: reductions in private motorized transportation and increases in public and non-motorized modes of transport, increases in the fuel efficiency of vehicles and the use of alternative fuels, and promotion of density and efficient public transportation. These actions have concrete and measurable co-benefits. Annex 4 summarizes the policies that 15 cities around the world have adopted to increase their efficiency and reduce the negative environmental impact of emissions.

To increase ridership on public transit, cities have improved the existing public transportation network, subsidized the cost of transit (for examples from China, see Hu et al. 2010), improved the safety of the system, and made efforts to better communicate service times and delays to customers. Cities have also facilitated biking—for example, by replacing lanes for vehicle traffic with protected bike-only lanes and by installing clear signage of bicycle routes and rights-of-way (as in Montreal, Paris, and Rio de Janeiro). Local authorities can also pursue alternative modes of transport to manage freight movement. Some European port cities provide incentives for alternatives to truck transport: Antwerp provides subsidies for inland river transport, while Rotterdam has dedicated freight railways.

To reduce emissions from urban transport, the alternatives include reducing emissions per kilogram of fuel combusted by replacing the usual fossil fuels with less polluting fuels (for example, natural gas or electricity); reducing the fuel combusted per kilometer traveled, by promoting greater vehicle efficiency; and reducing the vehicle-kilometers traveled through measures such as congestion charges (Box 25), vehicle registration quotas, and replacement of private motor vehicles by public transportation.

BOX 25

Congestion Pricing

Policy tools such as congestion pricing have been successful in reducing demand for private transportation. For example, London's congestion charge has reduced congestion by an estimated 30 percent between February 2003 and February 2004 in comparison to the same period in previous years (Transport for London 2004), and carbon dioxide emissions from traffic inside the charging zone were cut by 19.5 percent (Carslaw 2005).

Congestion costs are even higher in rapidly growing developing-country cities. The costs of congestion are estimated at 3.4 percent of local GDP in Buenos Aires, 2.6 percent in Mexico City, and 3.4 percent in Dakar (World Bank 2002). Mexico City and Bogotá have introduced number plate restrictions with measurable impacts on congestion and air quality (Mahendra 2008).

Complementary measures including fiscal policy (fuel tax, vehicle tax, congestion, and parking charges), regulatory policy (fuel standards, emission standards, and vehicle inspection), urban planning (high density and transit-oriented development), and temporary subsidies and tax breaks can also be used to contain rising emissions from urban transport in developing countries. In addition, many countries promote the purchase of ultra low-carbon vehicles through subsidies. In Belgium, Canada, China, the Netherlands, the United Kingdom, and the United States, those subsidies can be as large as $7,000 per vehicle (Perkins 2011). While developing countries may not be able to afford such high consumer incentives, they can reduce urban transport emissions by speeding up the turnover of the vehicle stock. Temporary subsidies and tax breaks may encourage people to trade in their old, higher-polluting vehicles and promote environmentally friendly transportation choices like compressed natural gas (CNG).

The introduction of cleaner transport fuel has major air-quality benefits. In response to extreme deterioration of air quality in Delhi, the Supreme Court of India passed an order in 1998 to reduce vehicular pollution. It called for replacement of all pre-1990 automobiles and taxis with new vehicles using clean fuels, conversion of buses older than eight years to CNG or other clean fuels, and steady conversion of the entire city bus fleet to a single clean fuel mode by March 31, 2001. Since 2001, Delhi has become the city with highest fraction of CNG-run public vehicles in the world. The impact of CNG conversion has led to a very large improvement in air quality. Between 2000 and 2003, there was a 34.8 percent reduction in emissions of sulfur dioxide, 2.8 percent in small particulate matter, and 7 percent in PM10 (Chelani, Asha, and Devotta 2007).

Green concerns are present in many large cities' transportation plans. In recent years, older, more established cities such as Amsterdam, Copenhagen, London and New York have invested in pro-cycling and walking strategies, while younger cities such as Bogotá, Parana, and São Paulo have invested in bus rapid transit solutions with well-established success. The plan prepared by Beijing for the 2008 Olympics focused on public transportation (metro and light rail), stringent vehicle emission limits, encouraging the use of automobiles powered by cleaner fuels, converting 90 percent of public buses and 70 percent of taxis to cleaner energy, and pricing downtown parking lots. In Hong Kong, to reduce vehicle emissions, the city is expanding and upgrading the public transport infrastructure with an emphasis on railways and using tax incentive schemes for environment-friendly private cars and commercial vehicles. This tax incentive system includes a 30 percent reduction in the first registration tax (FRT) for vehicles that have at least 40 percent higher-than-average fuel efficiency in the corresponding private car class.[12]

In the case of Singapore, the city energy program is committed to (a) increasing the share of public transport modes from 63 percent to over 70 percent in the next 10–15 years; (b) promoting less polluting cars with a green vehicle rebate; (c) raising consumer awareness with a fuel economy labeling scheme; and (d) managing road congestion through infrastructure development, refinement of car ownership and usage restraint measures such as an electronic road-pricing system.

Water

Sustainable cities face two main issues regarding the water sector (Miller and Yates 2006). First, they need to prepare for potential disruptions in water supply associated with global climate change. A recent study indicates that 61 percent of cities foresee substantive risks to their water supply in the future (CDP 2012); the two most common risks are increased water stress or scarcity and declining water quality. The next chapter looks at addressing these risks in the context of climate

[12]http://www.epd.gov.hk/epd/english/climate_change/transport.html

change adaptation. Second, the optimal approach to making the water sector more efficient and less greenhouse gas-intensive needs to be determined.

Water provision is carbon intensive because of the energy used to extract water, treat it, pump and distribute it, and collect and treat wastewater. In many developing countries, water utilities bear the cost of energy losses caused by inefficient distribution networks, losses in the underground water network, and inefficient pumping stations. Annually about half of the clean water is lost. To save water, greenhouse gas emissions and money, water authorities can improve water pumping installations, which are generally over-designed and hence consume more energy. They can also use renewable energy such as solar or wind power for pumping, although this may incur initial higher costs. In addition, integrated water management involving rainwater harvesting, separation of wastewater by source and water-efficient fixtures can lead to energy savings and greenhouse gas reductions.

Many cities are currently planning for and financing investments in water infrastructure retrofits, which can be cost-effective when financing for new infrastructure is hard to obtain. Cities also need to promote more efficient water management through smart water policies and better information for consumers. As in the case of energy, decentralized systems may be an alternative to centralized, piped water supply systems, particularly in fast-growing cities in Africa and Asia. Water conservation can be encouraged by proper pricing, efficiency standards for appliances, incentives to use low-flow appliances, education and information outreach, and focused efforts to promote conservation (OECD 2011b).

Moreover, cities could pass regulations to increase the use of recycled water. For example, in Melbourne, households are required to use recycled water (metered and delivered separately) rather than potable water for toilet flushing, washing cars, and landscape watering. A study of 12 cities in Canada and the United States found that watering restrictions on outdoor watering could be replaced by drought pricing, leading to equivalent water savings (Mansur 2007). Toronto's Water-Saver program provides cash incentives for industrial and institutional facilities to reduce water consumption. The reductions in consumption are high enough to enable the city to buy back water or sewer capacity (OECD 2011b).

Solid Waste Management

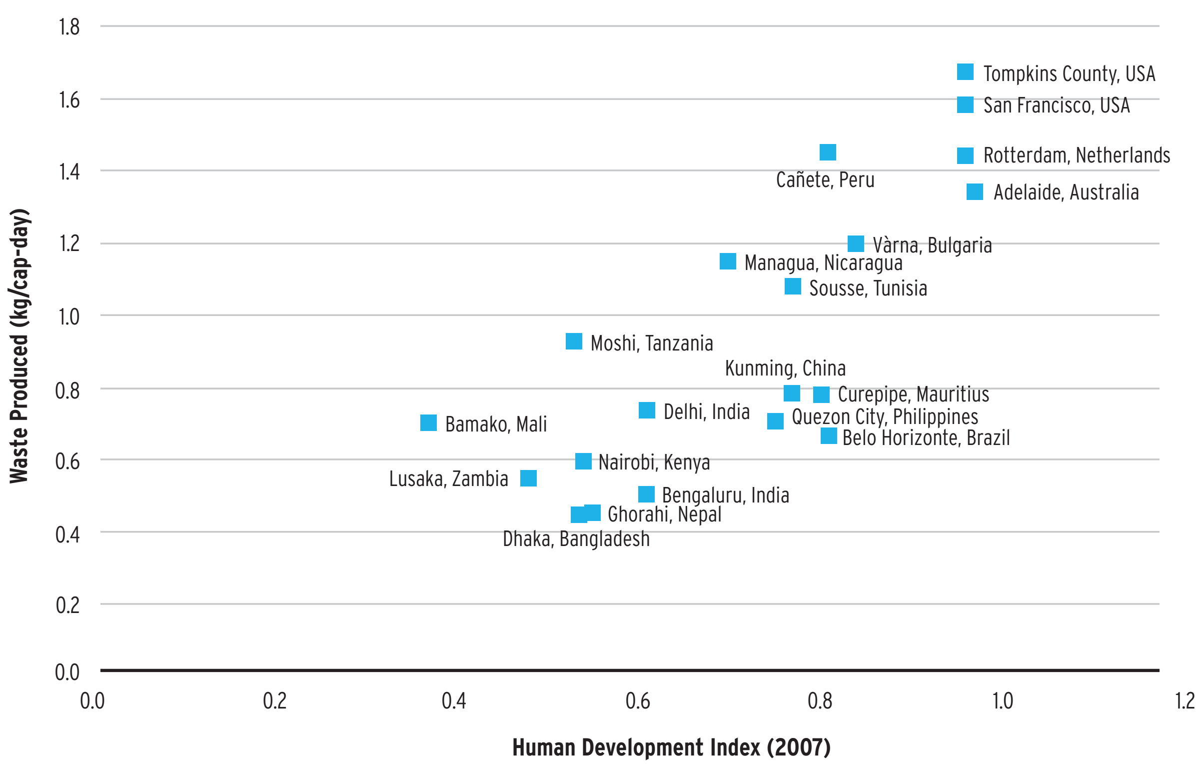
Effective management of municipal solid waste (MSW) poses "one of the biggest challenges of the urban world" (UN-Habitat 2010a). Global waste production is increasing; currently, the world's cities produce 1.3 billion tonnes of waste annually, and they will produce 2.2 billion tonnes by 2025 (Hoornweg and Bhada-Tata 2012). This waste directly affects environmental and public health at local and global scales, and the task of managing it in a socially, environmentally, and economically acceptable manner falls almost entirely to cities.

On a local scale, improper waste management, especially open dumping and open burning, pollutes water bodies, contaminates air and land, and attracts disease vectors. People who live near or work with solid waste have increased disease burdens (Giusti 2009). On a global scale, solid waste currently contributes to climate change (emitting 5 percent of total greenhouse gases), though waste has the potential to be a net sink of greenhouse gases if it is used as a resource through recycling and reuse (Bogner et al. 2007). Some air pollutants emitted via waste incineration, such as dioxins and furans, mix globally and thus affect the Earth's ecosystems and air quality.

In any given city, waste management can be described in terms of six components: generation, collection, source handling, transport, treatment, and disposal (Tchobanoglous and Krieth 2002). The chain begins with waste generation, which varies with wealth, culture, climate, demographics, and time. As such, waste quantity and composition are location- and context-specific. Generally, waste quantity and complexity increase with affluence and urbanization. The amount of MSW per capita appears to be positively correlated with development, as measured by the Human Development Index (Figure 14), as well as with urbanization (Figure 15). But while citizens of all urbanized regions tend to produce more waste, OECD residents are global outliers, generating far more waste than those from any other region (Figure 15). Other variables such as wealth and culture contribute to this greater waste generation.

Figure 16 shows that the large expected increase in urban population (particularly in Africa; see Annex 1) will bring commensurate increases in waste. This figure does not show causality, but does suggest future growth in waste production as the world urbanizes and develops. Note that, while rates of MSW generation per capita are already declining in OECD countries, Sub-Saharan Africa and South Asia are not projected to reach "peak waste" generation before 2100. This is problematic because these two regions will also have the highest total urban populations by 2100, followed by East Asia and the Pacific, whose waste generation rates are projected to plateau only by 2075. Latin America and the Caribbean, the Middle East and North Africa, and Eastern Europe and Central Asia are projected to reach peak waste by approximately 2050, but the impact of this earlier peak will be less significant because these are not the regions where urban population growth will be concentrated.

FIG. 14
Waste Production Per Capita



Source: Vergara and Tchobanoglous (2012)

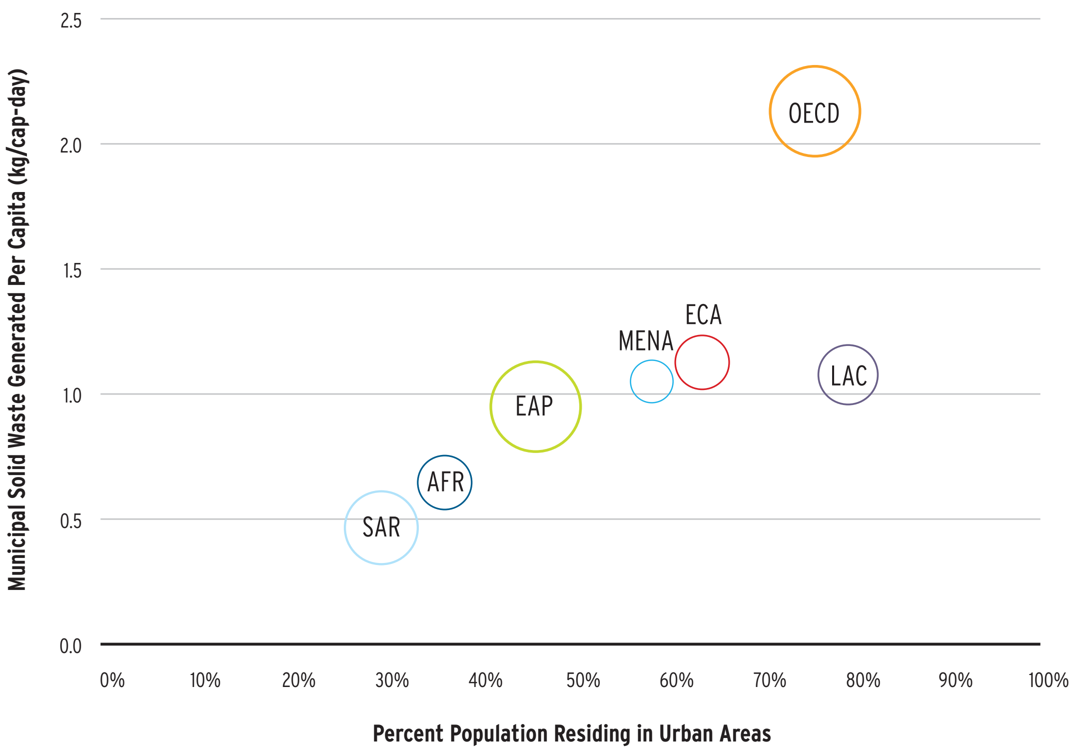


FIG. 15
Current Waste Production and Urbanization, by Region

Source: Data from Hoornweg and Bhada-Tata (2012).

Note: The size of each circle corresponds to the total amount of waste generated in the region. AFR, Africa; EAP, East Asia and Pacific; ECA, Europe and Central Asia; LAC, Latin America and the Caribbean; MENA, Middle East and North Africa; SAR, South Asia.

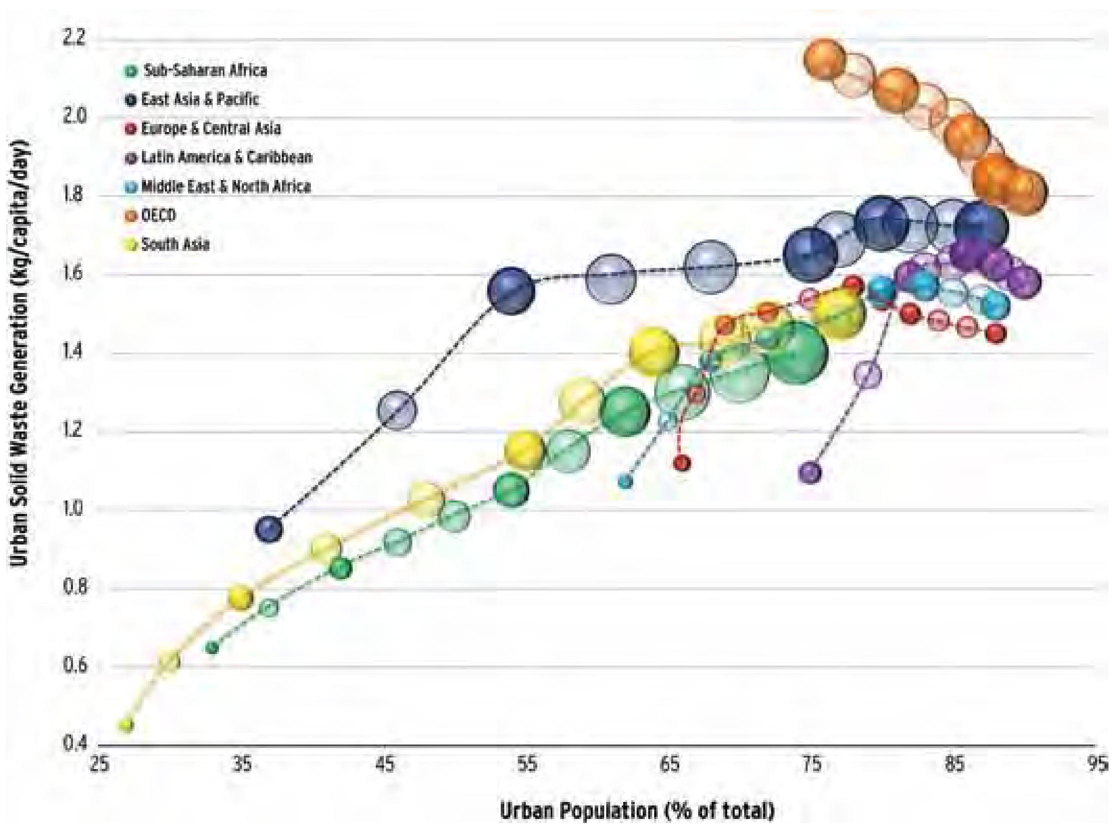


FIG. 16
Projected Waste Production and Urbanization by Region in 2100

Source: Data from Hoornweg and Bhada-Tata (2012).

Note: The size of each circle corresponds to the total amount of waste generated in the region.

The composition of the waste that cities generate changes with demographics. Wealthier cities tend to produce more complex waste, with a higher proportion of electronics and plastics, which are harder to manage. Electronic waste poses a particular threat to developing cities, since it contains toxic materials and is often exported from wealthier to poorer nations, where it is informally managed (Williams 2008). Lower-income cities tend to have a higher relative organic fraction in their waste; this less complex waste is relatively easy to manage. However, the global proliferation of disposable consumer products is increasing the complexity of waste everywhere.

To deal with more difficult waste, cities need to reduce waste production through market-based instruments such as weight-based waste fees (often known as "pay as you throw"). Another possibility, borrowed from the energy sector, is positive feedback mechanisms. In one study, residents received their energy bills along with information about the average community consumption, marked with a "smiley face" if they used less energy than average. The residents who saw this positive feedback reduced their consumption even further (Thaler and Sunstein 2008).

The next component of waste management, collection, is an essential precursor to further waste treatment. Collection rates in low-income cities are low (<50 percent), and collection costs represent a high fraction (80–90 percent) of municipal waste budgets. For middle-income cities, collection is more widespread (50–80 percent) and represents a smaller portion of the MSW budget. High-income cities spend a smaller portion on collection (<10 percent of MSW budget), because they spend much more on processing and treatment, and they tend to have high collection rates (>90 percent) (Hoornweg and Bhada-Tata 2012). In developing cities, where the informal sector plays an important role in providing waste management services, integrating these actors to maximize collection and waste treatment is important.

Cities can choose from a number of waste treatment technologies that convert waste to more useful products and mitigate environmental and health risks. Biogenic waste can become a nutrient source through composting, electricity via anaerobic digestion, or liquid fuel through conversion to ethanol or biodiesel. Technologies that transform biogenic waste are particularly applicable in less industrialized cities (and rural areas). Non-biogenic waste can be reused, or made into new products, via recycling; it can also be converted to energy, via thermal processes (incineration, pyrolysis, and gasification). Recycling is globally ubiquitous, though the formality of its practice varies; thermal treatment is most appropriate in places that are rich in financial and technical resources.

Finally, all waste management systems need a safe method for disposal. A continuum of disposal options exist in practice, from open dumping—which poses the greatest environmental and health hazards—to sanitary landfilling (engineered facilities designed to collect and treat all of the waste's byproducts).

Efforts toward sustainable waste management include a number of conceptual approaches. The "waste hierarchy," developed in the 1990s, ranks environmentally sound waste treatment technologies. Two recent schools of thought, integrated waste management and industrial ecology, aim to see waste as a resource. Integrated waste management is a set of principles—rather than a prescription—that aims to minimize the environmental and health burden of waste while maximizing its beneficial reuse and safely disposing of waste that is not reused. The field of industrial ecology proposes that waste management in human systems could mimic natural systems; it challenges the concept of waste, instead viewing all outputs as inputs into other processes.

Another approach taken by some cities, in the context of green growth and sustainable urban development, is to use greenhouse gas emissions as a metric to assess the sustainability of their waste management systems. However, waste management professionals know that there is no one-size-fits-all solution to waste management. Cities need local, innovative methods, adapted to their residents, their waste, and their resources.

Further Reading

Annex 4 summarizes policies for reducing emissions and increasing efficiency in 15 cities around the world.

Annex 5 presents an infrastructure sustainability rating tool created by the Institute for Sustainable Infrastructure (ISI) and partners.

Annex 6 discusses the concept of engineering for sustainable development.

4 Building Adaptive and Resilient Cities

Key Messages

- **Cities, regardless of their level of development, are particularly vulnerable to disasters and shocks because they concentrate people and enterprises. Many of the world's largest cities are located on low-lying coasts, rivers and other vulnerable areas where the impacts of climate change will be most severe.**

- **The need for cities to reduce their emissions is well-established, but the need to adapt to climate change and build resilience in cities is not as widely integrated into urban planning. Integrating mitigation and adaptation efforts at the local government level is critical as it will lead to more robust climate change policies and strengthen climate action in cities.**

- **As cities prepare for changing weather patterns, they become more resilient. Resilient systems have the capacity to absorb external shocks and continue to function by reorganizing and adapting. In fact, change and disruptions can create opportunities for development, innovation, and prosperity in a resilient city.**

- **Urban resilience increasingly depends on multi-sectoral partnerships involving local government action, private sector participation, and community-based risk management.**

While many developing cities will have the opportunity to avoid the path of their partners in the global North and adopt greener growth, the threat from climate change is significant. The new wave of urban investment should provide an opportunity for cities to consider and design adequate protection against warming temperatures, erratic weather, natural disasters, sea level rise, floods, droughts, and other potential consequences of climate change.

Not only have cities have contributed the largest share of the world's greenhouse gas emissions, they also concentrate many of the people most at risk from the effects of climate change—and the enterprises that generate most of the gross world product (Satterthwaite et al. 2009). These patterns do not necessarily overlap; most of the cities that face the highest risks are those with small greenhouse gas contributions, and most also have serious constraints on their capacity to adapt to climate change (see Box 26). But although the need for cities to reduce their emissions is well-established, the need to reduce urban residents' climate vulnerability is not.

Thus, urban adaptation efforts are only in their initial stages. At a minimum, a well-planned, well-established, successful city will already have taken measures in the past to ensure its ability to withstand extreme weather events. However, urban planners and managers must now consider measures to adapt their cities' buildings, infrastructure, industry, institutions, and services to the impacts of climate change. There are many ways to do this, ranging from adjustments in building codes and land use regulations to the use of insurance to spread risk, to effective, well-established emergency management services (Sattherthwaite et al. 2009). Going forward, these

BOX 26

Glossary of Terms Related to Adaptation

- ***Adaptation and mitigation linkages:*** Mitigation results in avoiding adverse impacts of climate change in the long run (at least the incremental impacts due to greenhouse gas not emitted), while adaptation can reduce the unavoidable impacts in the near term (but cannot reduce them to zero). Failure to mitigate will lead eventually to failure to adapt; hence, adaptation and mitigation are not alternative strategies but complementary ones that need to be pursued together (Sattherthwaite et al. 2009).

- ***Adaptive capacity:*** Inherent capacity of a system (such as city government), population (such as a low-income community in a city), or individual/household to take actions that can help avoid loss and speed recovery from any impact of climate change. Elements of adaptive capacity include knowledge, institutional capacity, and financial and technological resources. Low-income populations in a city will tend to have lower adaptive capacity because they are unable to afford good-quality housing on safe sites and avoid dangerous livelihoods. There is also a wide range in adaptive capacity among city and national governments, relating to the resources available to them, the information base to guide action, the infrastructure in place, and the quality of their institutions and governance systems (Sattherthwaite et al. 2009).

- ***Maladaptation:*** Actions or investments that increase rather than reduce vulnerability to impacts of climate change. This can include the shifting of vulnerability from one social group or place to another; it also includes shifting risk to future generations and/or to ecosystems and ecosystem services. Many investments being made in cities are, in fact, maladaptive rather than adaptive, as they decrease resilience to climate change. Removing maladaptation is often the first task to be addressed, even prior to new adaptations (Sattherthwaite et al. 2009).

- ***Resilience:*** Resilience is a product of governments, enterprises, populations, and individuals with strong adaptive capacity. It indicates a capacity to maintain core functions in the face of hazardous threats and impacts, especially for vulnerable populations. It usually requires a capacity to anticipate climate change and to plan needed adaptations. The resilience of any population group to climate change interacts with its resilience to other dynamic pressures, including economic change, conflict, and violence.

- ***Urban resilience:*** The degree to which cities are able to tolerate alteration before reorganizing around a new set of structures and processes (Alberti et al. 2003). As such, it can be measured by how well a city balances ecosystem, economic, and social functions; by how it responds to gradual impacts like climate change or sudden impacts like natural disasters; and by its ability to capitalize on positive opportunities that emerge as a result of change (Berkes and Folke 1998, Barnett 2001, Alberti et al. 2003).

- ***Vulnerability:*** The propensity of social and ecological systems to suffer harm from exposure to external stresses and shocks (Stockholm Resilience Institute 2012). The term is often used as an antonym of resilience.

adaptation measures need to be integrated with plans to mitigate climate change through more efficient city systems (Box 27).

Climate Change Vulnerability in Urban Areas

There is consensus that large-scale disasters are increasing in frequency worldwide, largely due to weather-related events. Many of the extreme weather events that have caused significant economic and human loss in the past 60 years have taken place in urban areas or affected them indirectly (for example, through immigration from affected areas or interrupted service provision). Some of these weather events are considered to be early manifestations of climate change, and in future, profound modifications of the climate will in the future have considerably greater impacts on cities, from flooding to heat waves.

According to the Intergovernmental Panel on Climate Change (Parry et al. 2007), the estimated economic impacts of extreme weather in the past range from a 3 percent GDP loss in Central America as a result of an El Niño year to a 7 percent GDP loss for Honduras during Hurricane Mitch. These aggregate figures obscure impacts much higher than the average in some locations (Sattherthwaite et al. 2009). Disasters are a product of hazards interacting with a vulnerable population; understanding the intricacies of local vulnerabilities, along with the hazards to which a city is exposed (Figure 17), is essential to build resilience in urban centers.

BOX 27

Benefits of Integrating Mitigation and Adaptation

Mitigation will not progress quickly enough to avoid significant climate change impacts, hence adaptation is necessary. At the same time, given the scale of expected impacts, adaptation cannot be the only response to climate change. Both approaches are not only necessary, but complementary (Wilbanks and Sathaye 2007). Linking mitigation and adaptation at the local government level is expected to enhance and strengthen the potential impacts of both types of climate action. By not coordinating mitigation and adaptation efforts, urban planners run the risk of increasing local greenhouse gas emissions through adaptation measures or increasing local vulnerability as a result of mitigation measures. As an example, a stand-alone mitigation strategy might recommend a higher concentration of housing developments close to the city center, while an adaptation strategy could shed light on the fact that the city center is located in a flood-prone area, where high-density housing increases the vulnerability of local residents to disasters (Bizikova et al. 2008). Integrating mitigation and adaptation efforts minimizes the chances of duplication or maladaptation and produces more robust climate change policies to reduce the costs and negative impacts of climate change. For instance, improvements in building energy efficiency can reinforce both adaptation and mitigation goals (Wilbanks and Sathaye 2007). When the relationships between mitigation and adaptation are ignored, there is a risk of failure in both areas.

FIG. 17
Physical Effects of Climate Change Identified by Cities

Effect	% of Respondents	Top Three Sectors Affected
Temperature Increase/Heatwaves	85%	Human Health, Energy, Water
More Frequent/Intense Rainfall	79%	Buildings, Water, Transport
Sea Level Rise	67%	Buildings, Waste, Transport
Storms and Floods	58%	Human Health, Buildings, Water
Drought	42%	Water, Human Health, Energy

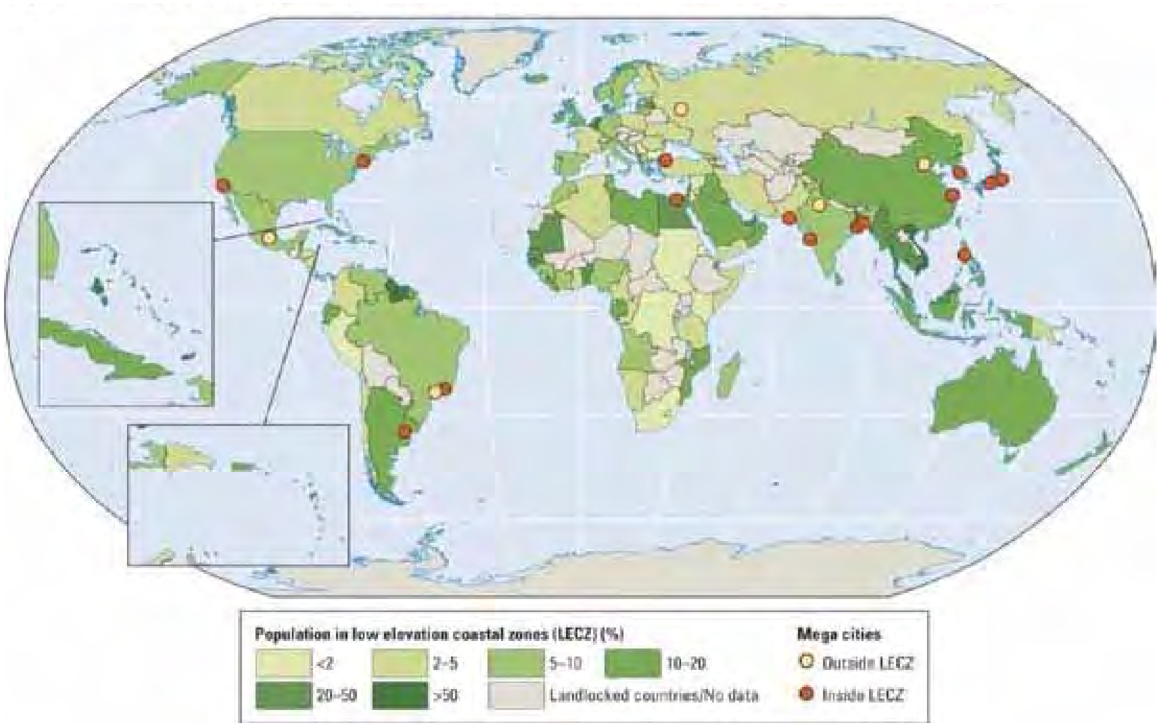
Source: Adapted from CDP (2011).

Cities face two types of climate-related risks: catastrophic and systemic. Catastrophic risks originate from poor design and location of the built environment, including infrastructure. These risks include losses associated with violent winds, temperature extremes, and sea level rise. An example is the Hurricane Katrina disaster that, in New Orleans alone, caused nearly 800 deaths, a loss of more than 90,000 jobs, and $3 billion in lost wages, with total financial losses estimated at $200 billion. The 2011 floods and landslides in Rio de Janeiro and São Paulo left more than 800 dead and 20,000 homeless. In Australia in 2011, Cyclone Yasi produced damages over $20 billion due to flooding alone, with a large percentage of this occurring in urban areas (ICLEI 2011).

Of the 20 megacities in 2008, 15 are in low elevation coastal zones that are most vulnerable to the sea level rise and storm surges associated with climate change (Figure 18). Many other large cities are close to river estuaries, coastal areas, and other vulnerable sites due to the historical advantages of these locations. And continued urbanization is putting an ever greater concentration of population and assets in these high-risk sites (Box 28).

Within cities, competition for land drives poorer urban dwellers to settle in higher-density marginal areas such as steep hillsides or flood plains, which further increases exposure. This combination of a higher degree of exposure and vulnerability of both people and assets within cities results in ever-greater social and economic impacts of natural hazards. Thus, emerging, urbanizing cities should prioritize risk mapping and develop policies in accordance with these findings. For instance, if a hazard map indicates flood risk in an up-and-coming coastal area of the city, urban planners can take preemptive measures and enact policies to ensure that industrial and residential areas are developed elsewhere.

FIG. 18
Megacities Threatened by Sea Level Rise and Storm Surges



Source: Reprinted from World Bank (2010c).

BOX 28

Urbanization in Coastal Areas

Many of the regions that are witnessing rapid urban growth and in-migration are located in coastal areas. This is of particular concern in the context of climate change where risk from sea-level rise and increases in the frequency and intensity of extreme weather pose a serious threat to the infrastructure and economic development of the city—not to mention its residents.

There is a tendency for private investments and enterprises to develop in coastal areas due to easy transportation access through ports. Such economic investments further reinforce the rapid urbanization in coastal areas. While larger companies and corporations could eventually choose to relocate away from risk-prone coastal areas and assume higher transportation costs, it is difficult to conceive a way in which entire coastal cities will effectively retrofit for climate-resilient development.

Large sections of cities with more than 10 million inhabitants (Mumbai, Shanghai and Dhaka, for instance) are at risk from sea-level rise. The economic success of these cities is critical for their overall nations' well being—both economically and culturally. In cities such as these, the exodus of private sector investment due to climate risk could have an important impact on the countries' economies.

Source: Sattherthwaite et al. (2009).

BOX 29

Case Study: Blackouts in India and the United States

Resilience is not just a challenge for low- and middle-income countries. Within a single month in 2012, both India and the United States experienced massive power outages that revealed vulnerable electricity grids.

On the east coast of the United States, severe summer storms knocked out power lines through several states. The blackouts at the end of June 2012 lasted several days—several weeks for many—affecting millions of people in the capital Washington, DC, and spreading from North Carolina to New Jersey and as far west as Illinois. A record-breaking heat wave followed the next week, when those without power had no way of combating the extreme temperatures. Ultimately, work crews from power utilities in Canada had to assist in the weeks-long effort to restore power.

In what has been called "the biggest blackout in the world," more than 700 million people in India were without power a few weeks later, after the country's electricity supply was overloaded by fast-growing demand—even though only 66 percent of the Indian population has access to electricity.[a] Three of the country's five electricity grids (four of which are interconnected) failed simultaneously, causing outages in 20 of India's 28 states, along with the capital, New Delhi. This led to cascading failures along thousands of miles of the commuter train system. It also affected the operation of hospitals and other crucial urban systems, such as traffic lights.

Such cascading failures indicate a significant lack of resilience in urban systems. In both rapidly-developing countries and the world's largest economy, energy infrastructure needs to be diversified from generation to transmission to distribution. We must address vulnerable links such as power grids if we are to bring about more sustainable cities.

a. http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

In addition to catastrophic risks, systemic climate-related risks arise from poor urban design and construction, as well as from interruptions to urban service provision and management systems. Systemic risks can lead to sustained losses due to highly inefficient systems for health care, energy, water, and food supply, arising from poor maintenance, old technology, and poor demand-side and life-cycle management. These risks have been graphically illustrated by sustained water and energy supply shortages in China, India, and western parts of the United States (ICLEI, 2011), and by blackouts in India and the eastern United States (Box 29).

Put another way, a city's resilience is determined not only by its exposure to hazards and the vulnerability of its population and assets, but by its institutional and community capacity to respond to stress. A paradigm shift is necessary to give equal emphasis to capacities, as opposed to the traditional technical approach of focusing on exposure to hazards.

The city network ICLEI looks at climate change-related risks as a subset of a larger pool of catastrophic risks confronting the world's growing cities and urbanizing countries, recently exemplified by the 2004 Indian Ocean tsunami and the 2011 Tohoku earthquake in Japan. Other disasters are the result of systemic risks, directly related to the enormous resource demands of growing cities that altogether account for some 80 percent of global energy demand. Trillions of dollars are being invested annually in global urban development, typically to design and build cities that embody chronic systemic risk and often extreme catastrophic risk. This is true even in affluent regions such as Japan, California's Silicon Valley, Vancouver's coastal plains, or the low-lying and hurricane-prone southern Florida area.

Adaptation Planning at the City Level

Adaptation to climate change can be defined as the set of organization, location, and technical changes that societies will have to implement to limit the negative effects of climate change and to maximize the beneficial ones (Hallegatte et al. 2011). Examples of adaptation actions include removing populations and assets from areas at risk, protecting infrastructure, adjusting energy networks to accommodate variations in energy consumption and climate, and preparing emergency response plans for extreme weather events (Box 30).

Climate change adaptation requires effective collaboration across sectors and between multiple stakeholders (Box 31). Cities are well positioned to convene a wide range of partners such as government agencies, local communities, nonprofit organizations, academic institutions, and the private sector. Under uncertain climate conditions, partnerships are key to a dynamic adaptation process that will allow cities to prepare, respond, and continue on their path toward sustainable development (World Bank 2011). Chapter 6 discusses the roles that different actors can take in such a process.

BOX 30

Keeping Cities Safe in Extreme Weather

Provision of basic services in cities is a key aspect of adaptation practice. In many cities, adaptation activities are already being mainstreamed in emergency planning to keep citizens safe and businesses operating in case of an extreme weather event. In Yokohama, agreements are in place with private companies to provide the city with food in case of a disruption to supply. Seattle has created a Vulnerable Populations Action Team Community Communication Network. This partnership between public health organizations, community-based organizations, and community leaders ensures that important health information reaches vulnerable populations in the event of an emergency. In Chicago, the city maintains an Extreme Weather Operations Plan that prescribes actions during times of extreme heat, cold, or severe storms. As part of the city's adaptation activities, the Department of Aviation Action is working to improve service for stranded passengers in the event of storms or extreme weather.

New York has several emergency and disaster response plans, including a Natural Hazard Mitigation Plan, a Coastal Storm Plan, a Citywide Debris Management Plan, a Power Disruption Plan, and a Flash Flood Emergency Plan. Johannesburg has developed a heat wave response plan, and many cities have programs to educate the public about how to prevent heatstroke and what to do in the event of a heat wave. A number of cities designate cooling centers for use by residents during extreme heat events.

BOX 31

Case Study: Growing Risks and Multiple Stakeholders in Altos de Cazucá

Urbanization processes are complex, involving many stakeholders, and incentives for growth and development can end up putting more people in the path of environmental hazard. An example is Altos de Cazucá, a district located in the mountain slopes of the Colombian Municipality of Soacha, the most densely populated municipality in the Department of Cundinamarca (which includes the capital, Bogotá). Soacha has a total population of approximately half a million people; accelerated population growth is mainly due to economic opportunities in the municipality and in neighboring Bogotá, as well as internal displacement due to armed conflict (AINCA 2008, p. 4).

The majority of properties in Altos de Cazucá are not titled or legally registered, and only 20 percent of the population has access to basic services such as drinking water, sewers, streets, or health services (OCHA 2006). Industrial activities are the main source of income in the municipality, and companies also facilitate development by providing certain services such as electricity to support company employees who live in the area (AINCA 2008, p. 24). One of the largest industries is mining; the mountains here are an important source of construction materials for Bogotá.

These mountains had been quarried in an unregulated manner for decades before they became populated, causing slope instability. Recurring small-scale landslides affect local livelihoods, and as the mountain slopes fill with people, more are harmed by these events.

According to several risk assessments, more than 40 neighborhoods in Altos de Cazucá cannot be legalized due to potential geohazards. Two different geologic risk assessments performed by the Ministerio de Planeación de Colombia (Urban Planning Ministry of Colombia) and the Japanese International Cooperation Agency have already determined that certain areas within the district are uninhabitable (JICA 2005).

While the private sector has supported the local population through service provision, the local government and other multilateral and nongovernmental institutions have grappled with relocation and other measures to make residents less vulnerable. The case of Altos de Cazucá shows that in a rapidly urbanizing area where different stakeholders are trying to support development, it is important to map risk and coordinate at multiple levels to build resilience (Baker-Gallegos 2010).

Photo: Julianne Baker Gallegos/World Bank

Most of the costs of adaptation will be borne by cities. Cost estimates are wide-ranging, but the UNFCCC estimates a global cost of $49–171 billion per year by 2030 (Parry et al. 2009), and the World Bank (2010d) estimates $80–100 billion per year. Currently, adaptation is financed mainly through private income, national and municipal revenues, grants from multilateral and bilateral institutions, and market-based mechanisms. There is ample room for cities to be creative in leveraging more funding from donors and collaborating with the private sector to help finance adaptation (World Bank 2011).

Adaptation can be reactive (after a disaster) or preventive (before a disaster). Politically, it is much easier to channel the necessary funds to adaptation after the fact. However, in economic and social terms it makes more sense to act preventively, as the costs to economic assets and the existing social network are substantially lower (World Bank 2011).

Public policies dealing with adaptation have four pillars: information, changing standards and regulations, improving institutions, and changing investment decisions. The first step in building adaptive capacity in a city is focused on information. In many cases, cities can gather data and map the communities, assets, and services that are vulnerable to climate-related risks, and have a clear understanding of how these could be strengthened to better confront impending climate change impacts. Providing all stakeholders with the best information available will help them handle the uncertainty around projected climate impacts (Box 32).

Often it is the responsibility of national or supranational agencies to produce knowledge relevant to impact assessment and adaptation, but local governments still play an important role in establishing early warning systems for city residents. A classic example is Havana, where a very effective early warning system ensures a low degree of damage when the city is hit by storms and tornados.

BOX 32

Incorporating Uncertainty in Adaptation Strategies

One of the difficulties in developing adaptation strategies is dealing with uncertainty. This uncertainty results from three components: 1) uncertainty about the global scenario of climate change (for example, a scenario with an average temperature increase of +2°C or one of +4°C), 2) how the global scenarios will translate at the local level,l[a] and 3) uncertainty about the reaction of major cycles (for example, water) and ecosystems to global and local climate changes.

The most effective method to take uncertainty into account is to ensure that stakeholders have the best information possible on the impacts of climate change and to encourage approaches that maintain flexibility for future action as additional information becomes available. However, adaptation strategies are complex because of the *dynamic* nature of adaptation; we do not adapt in a linear way, going directly from one point to another. We move from where we are now to a moving target: a perpetually changing climate. For example, a building constructed in 2000 with a lifespan of 150 years should be adapted to the current climate, as well as the climate in 2150, which will probably be very different from today's climate. The combination of uncertainty and long asset lifespan leads to the risk of maladaptation.

Source: Reprinted from Hallegate et al. (2011).

[a]For example, even for a given amount of global warming (measured as a change in global mean temperature), climate models diverge on the way in which climate change will affect the frequency and intensity of storm events in northern Europe.

As knowledge on new risks is obtained, the next step is to change standards and regulations. If long-term, forward-thinking policies are put in place, the costs of adjusting to climate change can be spread through time, making the adaptation process affordable. Furthermore, the process of reducing climate change risks can be designed to mitigate emissions and reduce other environmental risks at the same time.

During this process, local institutions have an additional role in balancing the interests of the different stakeholders, for example in the case of water scarcity or public-private partnerships. The fourth pillar of public action deals with the adaptation of existing public infrastructure as well as public buildings in general. New investments in infrastructure and buildings must also be adapted—in terms of size and location, for example—and should be complemented by policies that restructure land use, including major investments such as transportation networks, regional economic development projects, and so on.

Increasingly, cities are recognizing the need to plan for climate change by developing stand-alone climate plans or integrating them into existing plans and policies. *CDP Cities 2011: Global Report on C40 Cities* (CDP 2011) evaluated existing climate change adaptation plans, showing that about 25 C40 cities have such plans. Interestingly, all C40 cities in Africa and East Asia reported that they have climate change action plans, compared with less than half of C40 cities in Latin America.

Protecting Urban Water Supplies

The water sector provides a good example of complex climate impacts and the need for new plans and tools to manage urban resources. Climate change can affect water availability through well-known scenarios such as warmer and shorter winter seasons, increased glacial melting, more precipitation, changes in the recharge of groundwater aquifers, and warmer and potentially drier summer seasons (AMWA 2007). These changes will lead to shortages of water and/or to higher probability of floods.

There are indirect impacts as well. Severe storms and flooding will lead to water pollution from other sources, including wastewater treatment and storage systems. In most countries, wastewater treatment plants have not been designed for the likely changes in flow conditions due to climate change. As a result, it is conceivable that water suppliers will face challenges from sewage overflows, resulting in high concentrations of unhealthy bacteria. More than 60 percent of cities report that they foresee substantial risks to their water supply in the future. The two most common risks are increased water stress or scarcity and declining water quality (CDP 2012).

Besides the possible reduction of water availability and quality, local authorities need to anticipate shifts in demand for water. However, the water sector often suffers from insufficient capacity to solve technical and management problems as well as a lack of cross-sectoral coordination and financing difficulties.

Many water utilities have begun to respond to climate change by trying to understand how current plans could be disrupted and how to modify them. These efforts include vulnerability analyses to identify where impacts could be felt the soonest, and integrated resource planning (IRP) that looks at all possible alternatives for coping with systemic changes over the longer term. For example, technological advances such as recycled wastewater and desalination of seawater may be useful to address scarcity at the local level. Flood management—often under the responsibility of local governments—can be addressed in part by rainwater harvesting and the use of ecosystem services. An essential part of this integrated approach is the involvement of all stakeholders, as stakeholders have the capacity to redefine some of the objectives and constraints when such flexibility is necessary to avoid an impasse.

The IRP approach can also be used to manage water demand. Warming processes will change demand patterns as a result of shifts in precipitation, more evaporation, and more extensive droughts. Conservation incentives (and disincentives to outdoor water use) may become essential if warming processes increase water demands, especially during peak demand periods when both water supply and electric power capacities are stretched to their limits.

Can Adaptation Plans Reach the Slums?

Although planning for climate change is crucial, there is plenty of evidence that most urbanization in developing countries takes place outside of any plan or official regulations. The reasons include unaffordable housing in well-regulated areas, rural-to-urban and transnational migration, and the mismatch in institutional capacity to manage the growth of urban centers and economies. In Africa, Asia, and Latin America, hundreds of millions of people live in sub-par conditions, dealing with problems such as overcrowding, insecure tenure and inadequate provision of water, sanitation, health, electricity, and other services. This is particularly true in informal settlements, which comprise up to 50 percent of the urban populations in some developing-country cities.

Two factors limit a city's capacity to address these issues. First, urban governments tend to have limited human and fiscal capacity; finance is usually controlled nationally, and even when cities produce most of the country's GDP they are often dependent on higher levels of government for their resources. Second, urban governments tend to have an antagonistic relationship with low-income groups, particularly informal settlers, who are believed to hold back city success by remaining outside the formal economic system.

Photo: Julianne Baker Gallegos/World Bank

BOX 33

The Cost of Adapting Housing and Slums

Planned adaptation costs do not account for the high adaptation costs for urban housing, which are largely private. The World Bank estimated annual average household investments in urban housing in response to climate change at $2.3 billion per year in 2010, rising to $25.6 billion per year by 2050.

These costs would be even higher if they also accounted for slums. Most informal settlements in developing countries share characteristics that intensify the vulnerability of their residents to climate change. These include poorly constructed buildings, inadequate infrastructure, lack of safe drinking water, drainage, and sanitation services, and severe overcrowding with attendant public health impacts. In regions prone to flooding, floods are more severe in sprawling urban spaces than in inland towns, in part because of weak urban planning. The growth of urban slums increases the risk of climate-related disasters such as flooding and landslides, in part because natural ecosystem-based storm breaks and rain catchment areas are increasingly converted to public buildings and housing developments.

Source: World Bank (2010b).

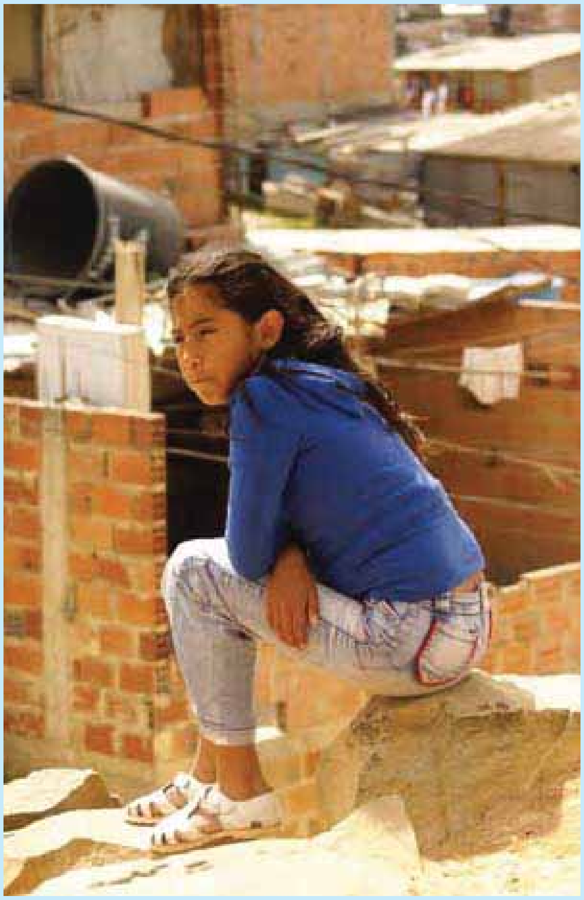


Photo: Julianne Baker Gallegos/World Bank

Cities will have to rethink their relationship with informality if they are to protect informal housing and informal economies from climate impacts. Strategic land-use planning in urban areas can help prevent residential and industrial development in high-risk areas, but it can simultaneously increase the cost of legal housing and service provision. This limits the possibilities for low- and middle-income households to rent or purchase adequate accommodations (Sattherthwaite et al. 2009). On top of that, the need to adapt urban homes to climate change imposes further costs that are not usually counted in government plans (Box 33).

Assessing Risks and Developing Resilience

As cities develop tools for managing climatic stresses and adapting to a changing environment, they become more resilient. The Stockholm Resilience Center defines resilience as the capacity of a system to continually change and adapt yet remain within critical thresholds.[13] Such resilience needs to be designed into policies for sustainable

[13] http://www.stockholmresilience.org/

management of social, ecologic and economic systems (Levin et al. 1998; Derissen et al. 2009).

Resilient systems have the capacity to absorb external shocks and continue to function by reorganizing and adapting. In fact, change and disruptions can create opportunities for development, innovation, and prosperity in a resilient system (Levin et al. 1998; Holling 2001). By managing for resilience and understanding that cities are exposed to uncertainty rather than seeing them as static systems, we increase the likelihood that development can be sustained under changing climatic and environmental conditions (Folke et al. 2002). As Holling and Walker[14] put it, "a resilient socio-ecological system is synonymous with a region [in this case, a city] that is ecologically, economically and socially sustainable."

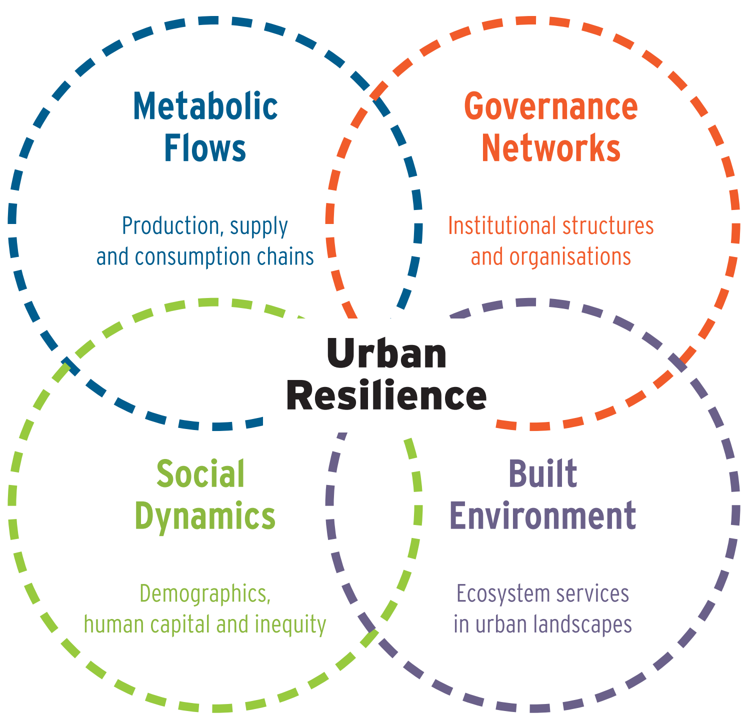
According to the Resilience Alliance,[15] the resilience of urban systems is in part determined by metabolic flows that sustain urban functions and societal well-being (see Chapter 5 and Figure 19). Among the other essential considerations in building urban resilience are:

- governance networks and the support provided by government to its society;
- the ability of a society to learn, adapt, and reorganize to meet urban challenges;
- social dynamics between citizens as community members, users of services, and consumers; and
- society's relationship to the built environment, which determines urban form and spatial relations.

[14]http://isecoeco.org/pdf/resilience.pdf

[15]http://www.resalliance.org/

FIG. 19
Essential Considerations for Resilience in Urban Systems



Source: Adapted from Resilience Alliance (2012).[16]

[16]http://www.resalliance.org/index.php/urban_resilience

Photo: Shutterstock

Adaptive capacity is also contingent on individual, household, community, or institutional resources (for example, income, asset base, knowledge, social networks, and effective and climate-resilient service provision). Particularly in urban areas, the quality and reach of public infrastructure and service provision is key, especially for vulnerable populations (Sattherthwaite et al. 2009). Hence, resilient cities are in essence urban areas that support sustainable income generation, good quality of service and infrastructure provision, and access to health, education, and information systems.

In accordance with this, the Swedish Environmental Advisory Council[17] argues that policies that manage for resilience will

- stimulate flexible and open institutions that encourage learning;
- provide incentives for inclusion and cohesion among different stakeholders and across sectors and disciplines;
- encourage ecosystem-friendly technology and economic incentives that enhance resilience and adaptive capacity;
- develop indicators for gradual change, as well as early warning systems to prevent shifts toward less desirable states;
- acknowledge uncertainty and expect the unexpected; and
- strengthen the perception of humanity, nature, and economic systems as interdependent.

Other key measures to build resilience include

- urban planning—for example, directing future growth away from risk or rezoning existing areas;
- investing in infrastructure—for example, building sea-walls, drainage systems, and earthquake-resistant construction;
- leveraging ecosystem services—for example, managing coastal ecosystems to mitigate erosion and storm surges;
- fostering social resilience—for example, strengthening community awareness and coping strategies; and
- creating insurance mechanisms to manage both public and private financial risks.

[17] Ibid

Ultimately, assessments of urban risk are the foundation for resilience and adaptation action plans. These risk assessments and action plans should be developed with the involvement of all relevant stakeholders.

Urbanization itself is sometimes seen as a driver of climate-related risk, but this can obscure the underlying, more specific risk factors. Urban planners can benefit from deconstructing the local causes and mechanisms of urbanization, and identifying the challenges and opportunities to build resilience within the system (Sattherthwaite et al. 2009). They can ask what is leading residents and industries to concentrate in high-risk areas, and develop urban plans that address these factors to promote urban development in areas exposed to lower climate-related risk.

Preliminary data exists on the risks cities are facing from climate change (Figure 17) as well as on the actions they are taking in response. While there is still a long way to go in data-driven and evidence-based policy making, it is important to push these efforts forward, because urban development initiatives that consider the impacts of climate change will be more durable in the long term. The next chapter looks at how sustainability and resilience could be better measured and monitored across the world's cities.

Further Reading

Annex 11 shows a multi-hazard risk assessment of the 100 largest urban areas.

Annex 12 reviews existing rankings of the world's most at-risk cities.

Annex 18 details the urban data that Earth observation satellites can provide, and its uses in planning and disaster risk management.

5 Measuring Urban Sustainability

Key Messages

- **Urban metabolism analyses look at how cities consume, produce and transform materials and energy. As measures of urban sustainability, these are more comprehensive and credible than a traditional ecological footprint.**

- **Data sources for cities have been improving, and metabolism indicators are now being calculated regularly and rigorously. All cities should begin measuring material flows and other environmental and social data. The Large Urban Areas Compendium initiated by the World Bank aims to support this.**

- **More standardized data enables cities to be compared in a typology. While requiring strong assumptions, this type of analysis sheds light on how cities are evolving in terms of their economic growth, urbanization and greenhouse gas emissions. Increasing wealth and urbanization usually lead to greater emissions, but some cities and countries have reversed the trend. Poor cities face a greater challenge in doing so, given their limited capacities.**

- **In addition to metrics for efficiency and environmental impacts, cities need a credible, standardized Urban Resilience Index. This would help focus attention on the urgency of mitigating risks from climate change in cities.**

To assess a city's sustainability, we need to consider how urban systems contribute positively to growth, prosperity, and social well-being, but also their level of "congestion costs" such as pollution, greenhouse gas emissions, and overcrowding. The benefits of density and agglomeration economies need to offset the costs of congestion for the city to continue to grow. Quantifying these trade-offs is not easy, but it is of great importance to policy makers.

In this chapter we use the framework of urban metabolism to understand how cities consume, produce and transform resources. We then consider how to select indicators to evaluate the sustainability of these urban processes. As part of the Sustainable Cities Partnership, the World Bank has begun a program to track key indicators in the world's largest cities.

Using two indicators—greenhouse gas emissions per capita and GDP per capita—we develop a simple typology for comparing and benchmarking cities. Finally, we consider how to apply similar metrics to assess cities' resilience to climate change impacts.

Urban Metabolism

The concept of urban metabolism—a means of analyzing a city's resource needs and pollution problems—originated with Abel Wolman (1965). Wolman first applied the idea to a hypothetical U.S. city of 1 million inhabitants, analyzing the flux of water, food, and fuel into the city and then out again in the form of sewage, solid refuse, and air pollutants. More generally, in the field of "industrial metabolism," the flow of materials and energy through a chain of extraction, production, use, and disposal is assessed in order to measure the impacts of anthropogenic activity on the environment (Fischer-Kowalski 1998).

Today, the problems associated with these fluxes are even more widely recognized as threats to sustainable development. The framework of urban metabolism can be used to measure not only environmental impacts, but also the economic and social dimensions of sustainable cities. Data on the consumption of material resources and energy can indicate the efficiency and intensity of economic production and the potential limits to growth. When metabolism information is spatially disaggregated, data on access to resources and penetration of urban services can be used as measures of social inclusion.

Research in this field has grown in the last decade, with urban metabolism studies currently supported by the European Union (Schremmer and Stead 2009), the State of California Energy Commission (2009), and the World Bank. Figure 20 shows one example, discussed further in Annex 8. Table 5 lists over 30 cities or regions for which urban metabolism studies have been conducted in some form. Some of these have focused on particular substances, while others have been more comprehensive. The list would be much longer if it also included cities that have completed greenhouse gas inventories, which entail collecting data on the energy inputs and waste outputs of cities (for examples of these cities, see Kennedy et al. 2009).

Urban metabolism studies to date have typically included fluxes of energy, nutrients, and materials, as well as the urban hydrologic cycle (Schremmer and Stead 2009). In the broader context of economic, environmental and social sustainability, urban metabolism might be defined as the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy and goods, and elimination of waste (Kennedy, Cuddihy, and Engel-Yan 2007).

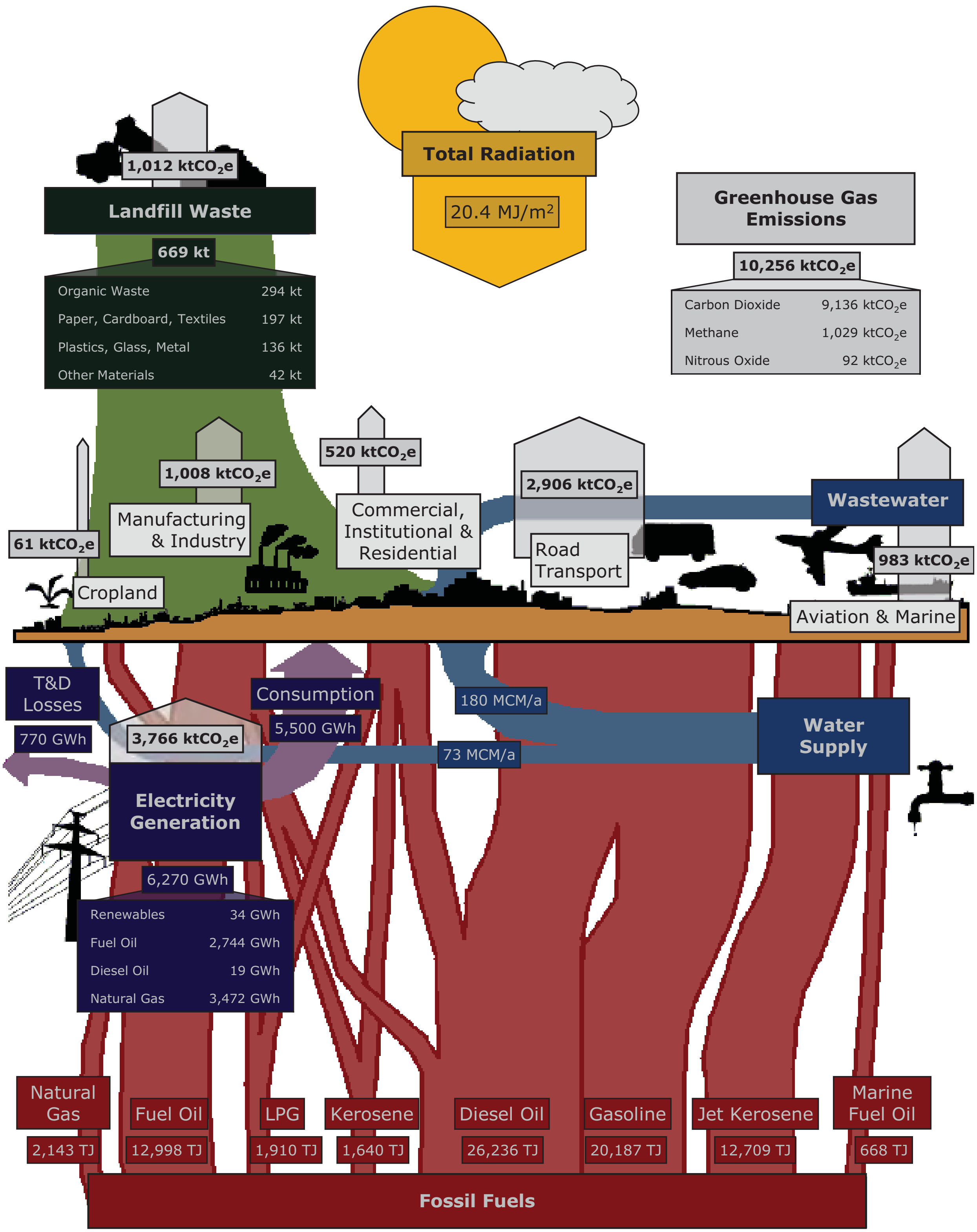
Conversely, sustainable development, in the specific context of urban metabolism, can be defined as "development without increases in the throughput of materials and energy beyond the biosphere's capacity for regeneration and waste assimilation" (Goodland and Daly 1996). Hence, any city aiming to develop sustainably must be aware of its metabolism—the inputs, outputs, and changes in storage of energy, materials, nutrients, water, and wastes. Such data is necessary for determining a city's

TABLE 5
Examples of Urban Metabolism Studies

North America	Europe	Asia	Australia
Los Angeles	Brussels	Amman	Sydney
Miami	Gävle, Sweden	Bangkok	Brisbane and southeast
Moncton, New Brunswick	Geneva	Beijing	Queensland
Phoenix	Hamburg	Hong Kong	**Africa**
Toronto	Leipzig	Jakarta	Cape Town
	Limerick, Ireland	Shenzhen	Dar es Salaam
	Lisbon	Singapore	
	London	Taipei	
	Paris	Tokyo	
	Prague		
	Swiss lowlands		
	Stockholm		
	Vienna		
	York		

Source: Kennedy (2011). See this reference for further sources and details.

FIG. 20
The Urban Metabolism of Amman, Jordan



Source: Reprinted from Sugar, Kennedy, and Hoornweg (2013).

greenhouse gas emissions, and it can also be used in the analysis of specific issues such as waste management or the supply of water and other scarce resources.

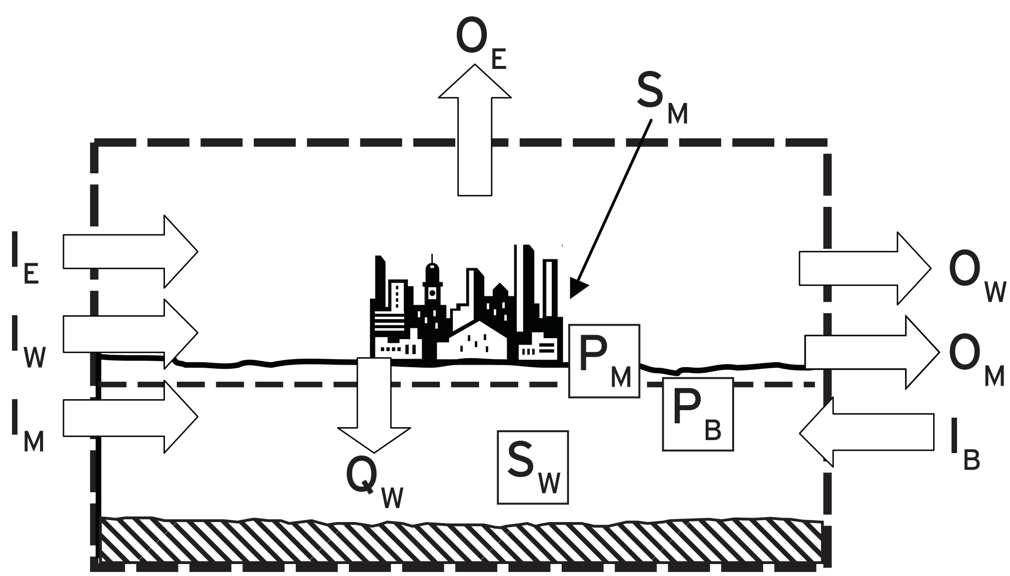
Measuring Inputs and Outputs

For cities that are serious about sustainability, quantification of urban metabolism is becoming a mainstream activity, and there is a growing need for a comparable, standardized approach to measure inputs and outputs. Two recent developments may help to meet this need: a comprehensive scientific framework for urban metabolism, and a draft list of ideal urban metabolism parameters.

A generic urban metabolism framework was developed at a workshop at MIT in January 2010 attended by urban industrial ecology researchers. The framework comprehensively captures all biophysical stocks and flows in the urban metabolism by integrating the Eurostat Material Flow Analysis model with methods of energy, substance, and water flow analysis (Figure 21). The system boundary will usually correspond to the political boundaries of a city, or to the amalgamation of city boundaries within a metropolitan region. It includes peri-urban activities such as food production and forestry, where applicable. Furthermore, natural components of urban metabolism, such as solar radiation and groundwater fluxes, are included together with anthropogenic stocks and flows.

Table 6 shows a draft list of the categories of urban metabolism parameters that cities should ideally measure. The list was vetted by participants at a "Sustainable Urban Systems" workshop in June 2011, at the International Society of Industrial Ecology's Sixth International Conference in Berkeley, California. Its contents reflect the

FIG. 21
Standard Urban Metabolism Classification System



Source: Reprinted from Kennedy and Hoornweg 2012.

Note: Urban systems boundary broadly showing inflows (I), outflows (O), internal flows (Q), storage (S) and production (P) of biomass (B), minerals (M), water (W), and energy (E).

TABLE 6
Categories of Urban Metabolism Parameters

Inflows	Production	Outflows	Stocks
Biomass (t & J) food wood Fossil Fuel (t & J) transport heating/industrial Minerals (t) metals construction materials Electricity (kWh) Natural energy (J) Water (t) Drinking [surface & groundwater] Precipitation Substances (t) e.g. nutrients Produced goods (t)	Biomass (t & J) Minerals (t)	Waste Emissions (t) gases solid wastewater other liquids Heat (J) Substances (t) Produced goods (t)	Infrastructure / Buildings (t) construction materials metals wood other materials Other [machinery, durable] (t) metals other materials Substances (t)

Source: Discussion among participants in the "Sustainable Urban Systems" workshop at International Society of Industrial Ecology, Sixth International Conference, Berkeley, California, June 7-10, 2011.

Note: Units are indicated in parentheses. t, tons; J, joules; kWh, kilowatt-hours.

urgency of pressing urban environmental issues, as well as knowledge of data availability and quality. Included are metabolism parameters required for accounting of both direct and indirect greenhouse gas emissions. The list also includes metrics that address other issues, such local air pollution, waste management, sustainable water use, and management of nutrients.

Since cities together have such large global impacts, all large cities should begin collecting urban metabolism data. The methodology described above is robust, standardized, and practical enough that cities should be able to use it with relative ease. It is well anchored in academic literature and complements related efforts that cities are already undertaking.

However, collecting data at the city level can be challenging for local governments. While all the parameters in Table 6 provide important parts of the picture, tracking the flows of many different types of goods and materials may become an overwhelming task, and some are more difficult to measure than others. To establish a standard set of urban metabolism measures and begin regular accounting of material flows, cities will need to become more proficient at data collection and dissemination.

Annex 7 shows data requirements for abbreviated urban metabolism studies, which can be undertaken by cities with limited resources or institutional capacity (Kennedy and Hoornweg 2012). The spread of technologies such as Earth observation satellites may help to fill in additional data (Box 34). It is also useful to look at urban indicators that are being measured in some existing initiatives.

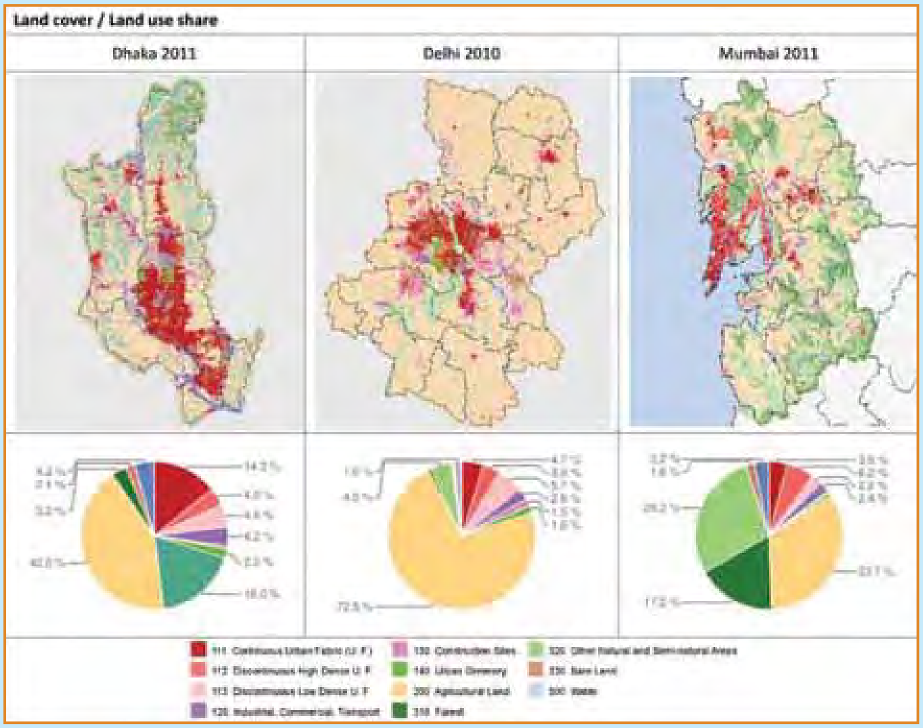
BOX 34

Earth Observation

Satellite datasets are increasingly used to drive assessment and analysis of spatial, environmental and temporal patterns of urban growth (such as urban expansion, land use, and housing densities), and they are becoming a standard reference technology in urban indicator monitoring and evaluation.

The major benefit of Earth observation (EO)-based monitoring is detailed and cost-effective digital mapping, which ensures that decision makers and planners have the most up-to-date and accurate data available on land use and land cover. Historical EO data archives also enable tracking of changes over time, providing insight into the evolution of urban agglomerations. Earth observation facilitates the collection of measurements in a harmonized and standardized manner, allowing spatially and temporally consistent global comparisons.

Samples from Spatial Comparisons of Delhi, Mumbai and Dhaka



Source: Reprinted from Eoworld project/GISAT for European Space Agency/World Bank (http://go.worldbank.org/5A2EGEFL90).

The potential uses for EO are many and varied, given that several key factors affect the extent and patterns of urban expansion: economic development, population growth, demand for housing, extension of transport networks, and so on.[a] Within an integrated geo-information environment, the spatial information can be combined with ancillary statistical, economic, and social data, allowing for more elaborate analysis. Examples are discussed in further detail in Annex 18.

a. http://www.eea.europa.eu/data-and-maps/data/urban-atlas/mapping-guide/urban_atlas_2006_mapping_guide_v2_final.pdf/at_download/file

Tracking Progress with City Indicators

Setting goals for improved urban performance or well-being has little purpose if there is no way to measure progress toward such targets. While there is as yet no consensus on how to define and measure urban sustainability, it is clear that in rigorous metrics are needed. Along with urban metabolism, measurements could also focus important aspects of sustainability such as resilience, greenhouse gas emissions and energy intensity, provision of basic services, and social equity, among others.

The need to monitor and manage city goals has led to a proliferation of urban indicator systems of varying scope, size, and focus. Two of the most ambitious are ICLEI's STAR Community Index and the Global City Indicators Facility (GCIF),[18] which is based at the University of Toronto. In addition, there are a number of other projects with similar aims:

- *STAR* is "a strategic planning and performance management system [offering] local governments a road map for improving community sustainability."[19] It is currently in development with 10 pilot cities and counties. It will eventually be linked to a set of consulting services that ICLEI provides its member communities to help them deal with climate change, financing, and other sustainability and operational challenges.

- *The GCIF* (Annex 3) was established in 2007 with funding support from the World Bank, based on a standardized set of indicators that the Bank developed to build globally comparable information on cities. The GCIF is now supported by the Government of Ontario and a number of international agencies and corporate partners. The indicators are designed to make it easier for cities to compare and share information about their operations and the well-being of their residents. With around 185 participants, the GCIF compiles Web-based datasets provided by its members through a standardized methodology using an established set of 115 metrics. Of these, 31 are "core" indicators, required from all members; 43 are "supporting" indicators that all cities are encouraged to collect; and 41 are profile indicators, basic statistics to help cities identify other peer cities for comparative learning. At present, while the GCIF is developing and testing this initial set of indicators, only cities that contribute their data gain access to the collective datasets. The GCIF represents a unique resource for measuring cities' progress toward sustainability and other performance goals, and the indicators are now undergoing standardization by the International Organization for Standardization (ISO).

- *The OECD's Metropolitan Regions database*[20] provides a range of socioeconomic indicators for OECD metropolitan regions, including population density, labor force characteristics, GDP and productivity rates, and employment and participation rates. To contribute to the understanding of the effects of urban dynamics on the environment and the well-being of urban residents, the OECD is currently expanding its metropolitan database to include a small set of environmental indicators to monitor the environmental performance of cities. Given the requirement of comparability, the OECD has prioritized indicators that can be derived from global sources, notably data from remote sensing and geographic information systems (GIS) tools.

- *The collaboration between C40 and CDP Cities* (CDP 2012) is another successful partnership for collecting and disseminating

[18] http://www.cityindicators.org
[19] http://www.icleiusa.org/sustainability/star-community-index/
[20] http://www.oecd.org/gov/regional-policy/regionalstatisticsandindicators.htm

standardized greenhouse gas emissions data and related climate change information from cities. C40 and CDP have collaborated to bring annual reporting—standard practice in the private sector—to city governments. CDP's reporting system is used by over 3,000 global organizations to make their climate change-related data available to the marketplace, including 48 major cities.

In addition to these comprehensive indicator programs, other groups are promoting more specialized or geographically localized urban metric systems.

- The Partnership for Urban Risk Reduction (PURR)[21] is a collaboration among United Cities and Local Governments, the Earthquake and Megacities Initiative, Metropolis, CityNet, and ICLEI, designed to help cities prepare more effectively for natural hazards and disasters. While the primary goal is to provide information, they also propose an Urban Risk Index to quantify cities' vulnerability.

- With more of an emphasis on the built environment, Siemens' Green City Indices (Annex 2) have now been released for several continents. They are intended to facilitate learning by ranking cities' environmental performance.

- Other measurement schemes are focused on specific aspects of urban systems, such as energy efficiency, social cohesion, or public health, or on more restricted geographic ranges, such as one region, country, or metropolitan area, or different parts of a single city.

These initiatives span a range of diverse metrics and methods. Measuring city performance consistently is surprisingly difficult, and cities are a long way from agreement on a common approach. A survey of eight city governments in North and South America (Hoornweg et al. 2007) found that each regularly tracked dozens to hundreds of indicators, but only two of the 1,100 total metrics were common to all eight cities.[22] The way in which information was stored and analyzed also varied widely.

This is particularly a problem for investment strategies and international policies intended to help cities around the world achieve global sustainability goals. Such programs cannot be successful without having consistent urban data upon which to evaluate decisions.

As with corporate-led urban initiatives, data-centric programs face a scaling challenge. They need to have a sufficiently large user base so that other cities feel compelled to join, leading to adoption of standard methods. Thus, one of the central questions is organizational—who has the authority to prioritize among non-standardized approaches, and how can the growing interest and enthusiasm for urban sustainability be more effectively stimulated and channeled? The Large Urban Areas Compendium—a new initiative from the World Bank, backed by the Sustainable Cities Partnership—is starting this process.

The Large Urban Areas Compendium

Urban indicators need to be measured, standardized, targeted, and compared across cities and over time. The Large Urban Areas Compendium (Annex 10) is a first step toward identifying what data should be collected on a regular basis, in order to focus policy making on underperforming sectors. Currently, most statistical information is collected at the national level, whereas many relevant policy decisions are made

[21] http://www.emi-megacities.org/purr/

[22] The cities were Belo Horizonte, Bogotá, Cali, Montreal, Porto Alegre, São Paulo, Toronto, and Vancouver.

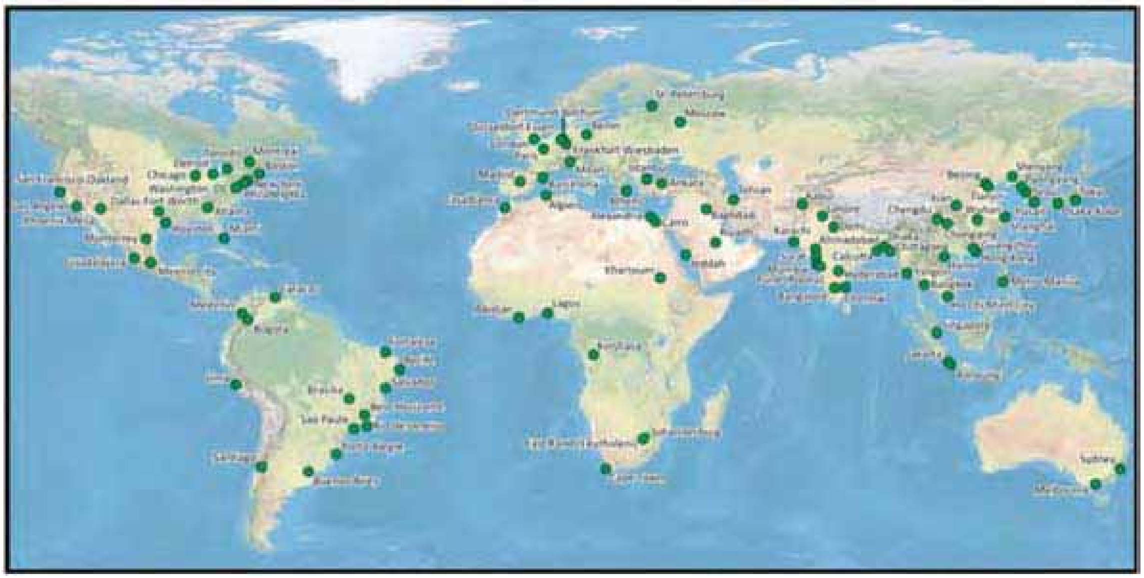


FIG. 22
The World's 100 Largest Urban Areas

Source: developed by Katie McWilliams and authors with data obtained from http://www.citymayors.com/

and implemented at the local level. Standard urban indicators should be designed to bridge the gap between the scale at which information is available and the level at which urban development is conducted.

To begin addressing this gap, the World Bank and partners such as the World Economic Forum and the World Business Council for Sustainable Development (WBCSD) will assemble, on an annual basis, existing key data and indicators for the 100 largest urban areas in the world (Figure 22 and Annex 9). With continuous updating of this compendium, better definition and data quality for all key metrics should emerge. These data can also be used to develop typologies for comparing and analyzing cities at different levels of sustainability and development (see next section).

The Large Urban Areas Compendium will complement and extend the work of the GCIF. GCIF is now finalizing an ISO-standard methodology for data collection, and GCIF member cities have already started submitting information on many urban indicators, but many have not yet released their data publicly. GCIF selected their indicators based on input from the partner cities, to ensure that they address city priorities, information needs, and challenges. The indicators were also designed to be "meaningful to cities across the globe regardless of geography, culture, affluence, size, or political structure."[23] To minimize duplication of efforts and additional burdens on local governments, the Large Urban Areas Compendium draws heavily on the existing GCIF metrics.

The set of indicators included in the compendium has several goals, but primarily these data are intended to present "vital signs." They should provide a snapshot of basic city functions and amenities, while diagnosing any problems and suggesting possible directions for improvement. In addition, some of the indicators were chosen

[23]http://cityindicators.org/themes.aspx

to monitor progress toward the Millennium Development Goals.

GCIF core indicators were adapted for the following themes:

- Economy
- Energy
- Emissions and pollution
- Water, sanitation and waste management
- Shelter
- Governance
- Transportation
- Education, technology and innovation
- Health

Additional indicators deemed necessary for the compendium include

- certain geographic and demographic characteristics;
- economic data, such as GDP and the Gini coefficient of income distribution, which provides a measure of economic inequality in the area;
- energy consumption, energy intensity of the economy, and electricity use;
- greenhouse gas emissions and intensity of the economy;
- urban metabolism indicators, such as water consumption and solid waste generation;
- measures of disaster risk, institutional capacity, and vulnerability (including vulnerability to the impacts of climate change);
- infrastructure inventories and need; and
- other health indicators.

The initial dataset for the Large Urban Areas Compendium is published in Annex 10 of this report. This is the first version of what is hoped to be an annual process. The samples in Annex 10 represent the best data currently available, but they have significant gaps and considerable ranges of estimates, particularly for the greenhouse gas emissions. Given the fundamental importance of cities and urban areas to the world's economy and environment, such paucity of data is unacceptable.

It is illustrative that there is no consensus even on what the world's largest urban areas are or where their borders lie (see Box 35). Today there are better statistical data, for example, on Fiji (population: 860,623) than there are for Delhi, Lagos, Rio de Janeiro, or Shanghai, all of which have populations in excess of 10 million. For future annual compendia, organizations such as the GCIF, C40, Metropolis and national governments, as well as

BOX 35

Where Are the Borders of the Largest Cities?

There is currently no consensus on the borders of the 100 largest urban areas, almost all of which are metropolitan areas made up of several municipalities. Sydney, for example, is made up of 38 local governments.[a] Internationally, the Lord Mayor of the City of Sydney may represent "Sydney," but only 4 percent of the metropolitan population is electorally represented by the mayor.

Urban areas might also be defined by regional or national governments, economic hinterlands, commuter-sheds, or other service hinterlands such as employment or travel nodes. For most of the truly significant municipal accomplishments in urban transportation, energy conservation, and solid waste disposal, metropolitan or regional approaches are necessary.

a. http://www.gnb.nsw.gov.au/

the individual urban areas and their constituent local governments, would be asked to move toward a consensus definition of at least the 100 largest urban areas of the world. For this inaugural effort, the list of 100 largest urban areas is taken from the City Mayors Foundation.[24]

As cities improve their data reporting through programs like GCIF, a temporary best available data approach could be used to monitor the world's 100 largest urban areas. This data would not be new, primary data, but would instead be a compilation of what is being collected and published by cities, agencies and higher levels of government. Eventually a hierarchy of data credibility is likely to emerge—for example, city-reported data consistent with ISO standards through agencies like GCIF would be the gold standard, while estimated values such as those for greenhouse gas emissions in Annex 10 are intended as placeholder values.

The list of urban areas is expected to change as a broader consensus emerges on borders and, of course, as populations change. Refinement is expected during the next several years as GCIF develops an aggregation function for its member cities, and as national governments and city-based agencies reach broader consensus on the definition of major urban areas. For the foreseeable future this list is expected to be published in several venues, such as the City Mayors Web site. Ideally, the methodology used to develop the list will be sufficiently robust to enable ISO standardization.

The hope is that this broad set of indicators will be made available by cities, updated annually, and shared through related publications and Web sites. In particular, changes in the indicators over time will be extremely relevant for public policy decision making. The next section offers basic examples of the type of analysis that can be conducted using indicator data.

[24]http://www.citymayors.com

Typology of the Largest Cities

Indicator data can be used to create a typology of cities, comparing them along various dimensions of sustainability and clustering cities with similar patterns. A typology can reveal relationships—for example, environmental burdens increasing along with wealth. It also identifies "outliers" that defy these tradeoffs and do far better than most cities, and can suggest the reasons for such differences. In sum, a typology can identify core sustainability challenges and help find ways to secure people's well-being while simultaneously taking advantage of opportunities to decouple urban development from carbon- and resource-intensity.

Underlying this methodology is the assumption that experiences of cities at more affluent stages of economic development are useful to developing country cities as they follow—or avoid—development paths used in the past. Success stories and cautionary tales may allow developing cities to take preventative measures or institute policies that will lead to lower-carbon development.

With this in mind, a typology based on a richer dataset could serve as a baseline for planners and the public to measure progress toward sustainability. Furthermore, in the absence of binding international agreements around climate change, a typology could motivate smaller-scale partnerships among cities within the same cluster or type. Awareness of other cities within the same peer group can facilitate tailored collaboration and action on certain touchstone issues, and enable peer-to-peer learning.

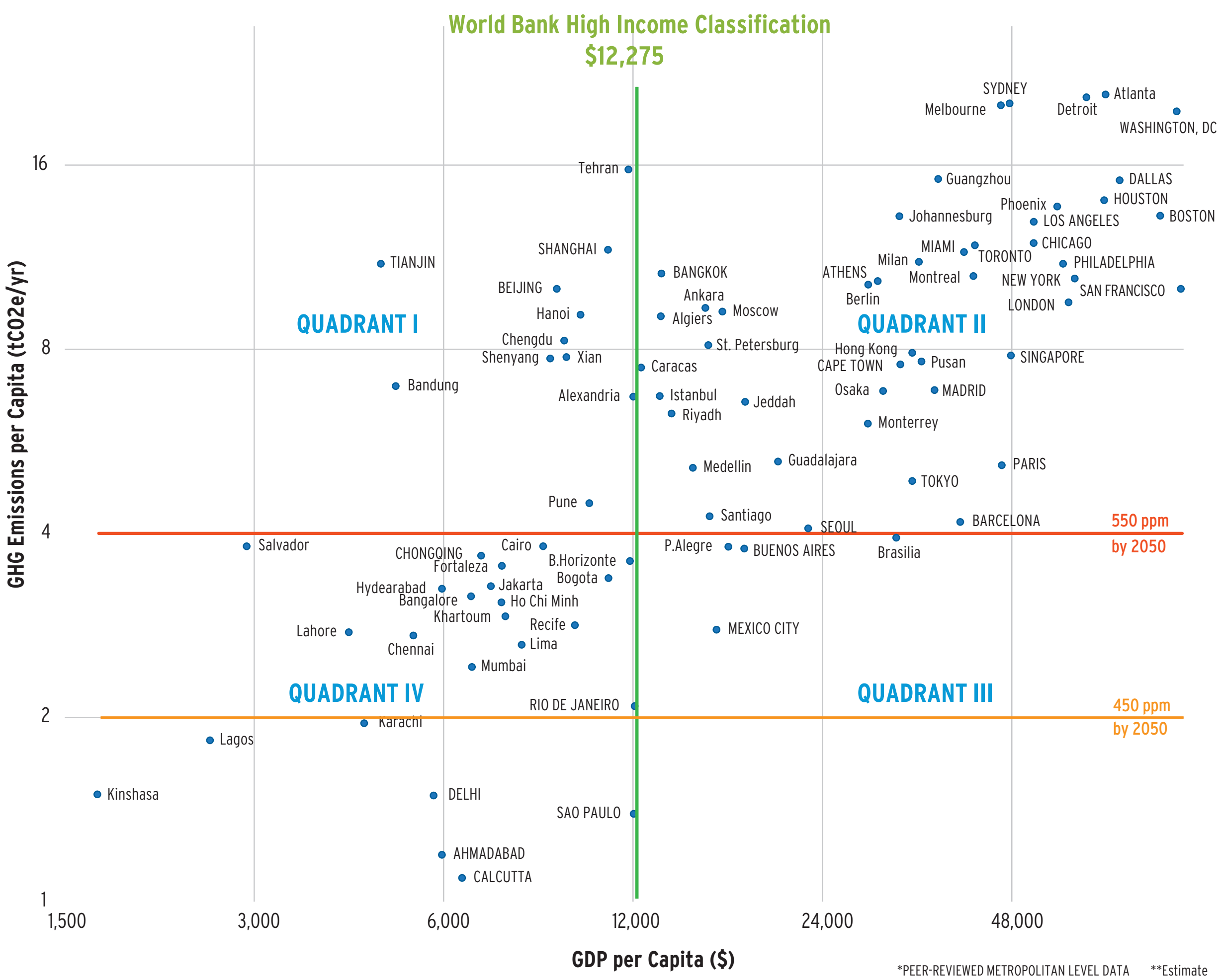
Sophisticated typologies are challenging to build, however. If defining sustainability based on a limited number of indicators is fraught with difficulty, categorizing cities according to their level of sustainability is even more complicated. Cities are not easily clustered by income, production, density, or even pollution, as variables combine to produce complex effects and categories are unclear.

These complications, however, should not hinder the exercise of clustering cities in pragmatic ways. Here this section proposes a relatively simple typology of cities. It situates cities along two dimensions: economic development, measured by GDP per capita; and one indicator of sustainability, namely greenhouse gas emissions per capita. Together, these two measures show the greenhouse gas intensity of GDP growth, calculated as emissions/GDP.

Of course, reduction of greenhouse gas intensity is not the only measure of urban sustainability; sustainability is a wide and controversial concept, and low-carbon development is only one (albeit important) component. For example, sustainability could be equally measured by water consumption or waste disposal. However, greenhouse gas emissions are more closely related to global warming. Similarly, in this preliminary work we have used GDP per capita as a proxy for well-being, but there are undoubtedly many other dimensions along which it must be measured.

In Figure 23, lists the 100 largest urban areas (based on www.citymayors.com) to analyze why cities at similar levels of development and income can exhibit different levels of sustainability. This graph is based in part on estimated data, and thus it only roughly

FIG. 23
Typology of the 100 Largest Urban Areas, Based on Emissions and GDP



Source: Author's calculations, see data in Annex 10.

Note: Capitalized city names indicate that data from peer-reviewed metropolitan-level greenhouse gas inventories was used. Greenhouse gas emissions for all other cities were estimated based on sectoral activity and national emissions factors. Values are provided and estimated for the world's 100 largest urban areas as listed on the City Mayors website. Estimates are indicative, and not directly comparable to values from actual greenhouse gas inventories.

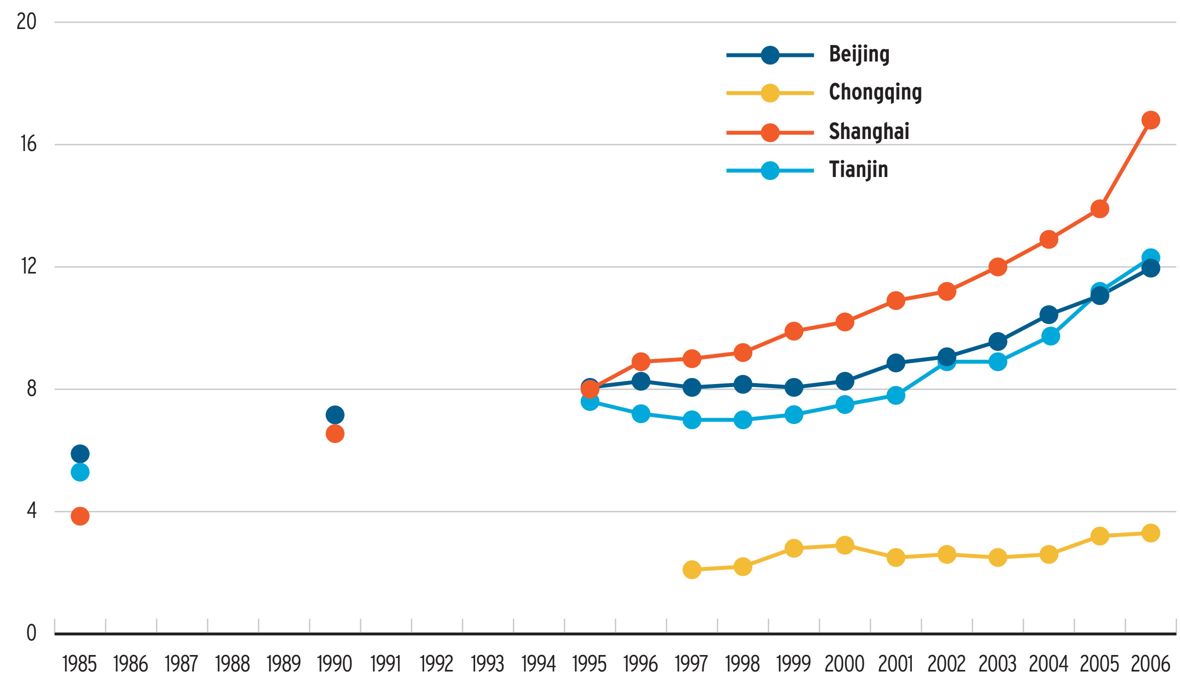


FIG. 24
Per Capita Carbon Dioxide Emissions from Four Major Chinese Cities

Source: Adapted from Dhakal (2009).

indicates the relative positions of cities. Better clustering requires high quality, open data from city-scale greenhouse gas emissions inventories.

Nonetheless, the four city types approximated by the quadrants in Figure 23 already point to useful information. In particular, cities are grouped according to (a) their level of income, as classified by the World Bank; and (b) whether their per capita emissions are within certain limits. Specifically, are a city's per capita emissions below the level of global per capita emissions according to the two IPCC scenariosof 450 or 550 parts per million (p.p.m.) of carbon dioxide equivalent.

The four categories are:

- Quadrant I: Per capita emissions above the 550 p.p.m. scenario and far above the 450 p.p.m. scenario, and low or medium income (annual GDP per capita of $12,275 or less).
- Quadrant II: Emissions above the 550 p.p.m. scenario and high income.
- Quadrant III: Emissions below the 550 p.p.m. scenario and high income.
- Quadrant IV: Emissions below the 550 p.p.m. scenario, and even below the 450 p.p.m. scenario in many cases, with low to medium income.

Quadrant I (lower income and high emissions) contains the three largest Chinese cities (Shanghai, Tianjin, and Beijing), with the fourth largest city, Chongqing, only slightly below the 550 p.p.m. line in Quadrant IV. Dhakal (2009) discusses the energy use and increasing carbon emissions of these four cities (Figure 24) and the underlying drivers and policy implications. Economic growth (particularly in the industrial sector until 1990) was found to be the dominant driver of carbon emissions. During the 1985–2006 period, Shanghai's economic growth was significantly higher than that of the other cities, resulting in the rapid increase of carbon dioxide emissions. During the 1990s, energy intensity (measured by greenhouse gas per output GDP) declined as the economic structure shifted from manufacturing to tertiary sectors. This decline in intensity slowed down in the 2000s—becoming negligible in the cases of Shanghai and Tianjin—and absolute levels of emissions have continued to rise.

Chongqing's substantially lower emissions are an artifact of its designation in 1997 as one of China's four directly controlled municipalities, along with the other three largest cities (Shanghai, Tianjin, and Beijing). Though all four cities are overseen by a single Mayor, in the case of Chongqing the municipality's jurisdiction was extended over 19 districts and 19 counties, giving it a land area larger than Taiwan. As such, the core city had a population of 5 million in 2011, but according to a 2010 article from the official Xinhua News Agency,[25] the municipality has a total population of 32.8 million, including 23.3 million farmers. Hence, the lower-consumption lifestyle of the rural residents decreases the value of per capita emissions for the municipality as a whole, while obscuring the impacts of the higher-intensity urbanized area.

Quadrant II (high income and high emissions) is dominated by the cities of the United States, for which carbon dioxide emissions from road transport (cars and trucks) and residential buildings (electricity and other fuels) account for approximately 45 percent of national carbon dioxide emissions (Brown 2009). This is consistent with the trend of sprawling U.S. cities and the growth of peri-urban and suburban communities with large, single-family detached houses. To some extent, this is also true of greater London, which has a relatively low population density and large numbers of residents who live in the suburbs and commute to work.

These developed cities are already above the level of per capita emissions that would lead to greenhouse gas concentrations of 650 p.p.m., triggering global warming of more than 5 °C and irreversible ecological damage, according to predictions from the IPCC (Metz et al. 2007) and Stern (2010).

In contrast, some other European cities in Quadrant II— Madrid and Paris—have denser urban form, smaller multi-unit housing, and more extensive public transport networks, which reduces car dependency. Accordingly, they fall lower in the quadrant, but still above the threshold for 550 p.p.m.

Very few cities can be found in the high-income, low-greenhouse gas emissions quadrant. Quadrant III includes Buenos Aires, Mexico City, and Porto Alegre. Mexico has the fourth largest installed geothermal capacity in the world, accounting for 3 percent of the total generation mix (Geothermal Energy Association 2010). Mexico City's Climate Action Program emphasizes efficient urban transportation, with the installation of bus rapid transit lines, renewal of the taxi and microbus fleets, construction of bicycle and pedestrian routes, and restriction of days when automobiles can be operated. Barcelona is an extremely dense metropolitan area with a highly developed public transport system.

Quadrant IV (low emissions and low income) contains predominantly middle-income Southeast Asian, South Asian, African and Latin American cities. Geothermal power is a significant contributor in some of these countries, with the Philippines generating 27 percent of its electricity from geothermal sources (it is the world's second largest producer behind the United States, although geothermal represents only 0.3 percent of U.S. power generation; Holm 2010, p. 7). Geothermal

[25]http://news.xinhuanet.com/english2010/china/2010-07/29/c_13420830.htm

energy represents 3 percent of national power generation in Indonesia, which is the third largest producer in the world. Hydropower is dominant in Brazil (86 percent of national generation) and represents 16 percent of the power mix in India. Both are among the top 10 largest hydroelectric producers in the world (REN21 2011).

Many Quadrant IV cities are growing rapidly, and as they continue to develop they are likely to move into Quadrant II unless policies prevent this. For example, car use is still much lower in Quadrant IV cities than in the U.S. cities of Quadrant II. However, sprawling urban growth, coupled with economic growth, will encourage private car ownership. Hence, integrated public transport and land use planning is essential, especially when addressing service delivery and housing provision for informal and low-income settlements.

Energy use in housing and buildings is another factor in these cities' emissions. Air conditioning is not yet widespread even amongst the middle- and higher-income residents, and because the Quadrant IV cities have mostly tropical climates, heating is not necessary. However, as with private automobiles, penetration of air conditioning (and other appliances) into the market will increase as household incomes grow. In the building sector, this growth could be curtailed by the adoption of low-energy designs that employ natural ventilation techniques. Vernacular, pre-electricity architecture may suggest culturally and environmentally appropriate building designs, particularly for residential structures. In rapidly urbanizing cities, this may be an important way to lower the impact of the immense number of new housing units needed in the coming decades.

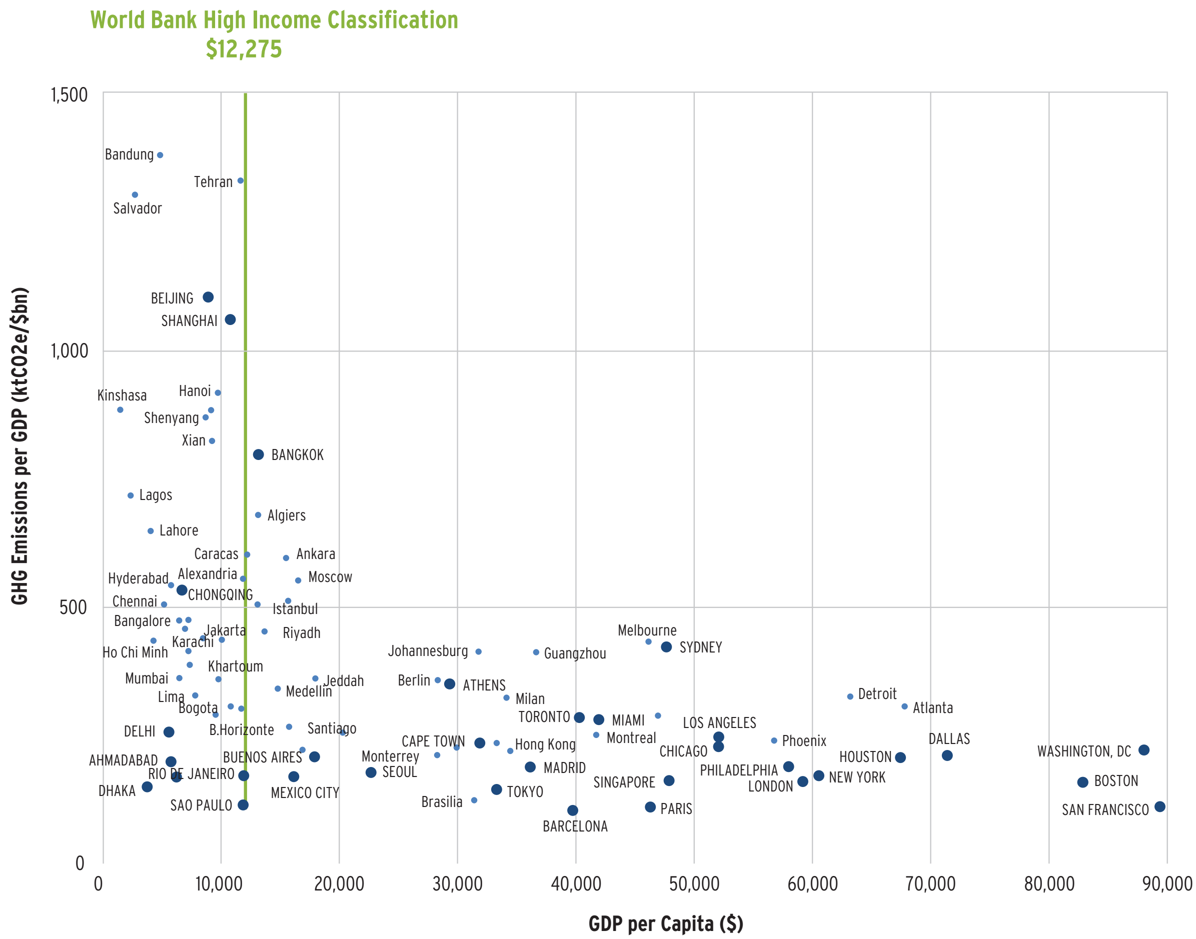
An analysis of particular cities in each quadrant could shed more light on what is behind the different emissions levels in the four quadrants. Greater pollution in some cities could be due to a larger manufacturing sector, urban sprawl, or the use of coal-based energy, for example. This kind of analysis could reveal the weight of each factor in explaining variations of greenhouse gas emissions.

Decoupling GDP from Emissions

Eventually, sustainability should lead to the improvement of the urban well-being and inclusiveness of growth. It was therefore important that our city typology differentiate between more and less greenhouse gas-intensive cities that are

Photo: Shutterstock

FIG. 25
Greenhouse Gas Intensity Versus GDP Per Capita



Source: Author's calculations, see data in Annex 10.

Note: See Figure 23 for a description of the data shown.

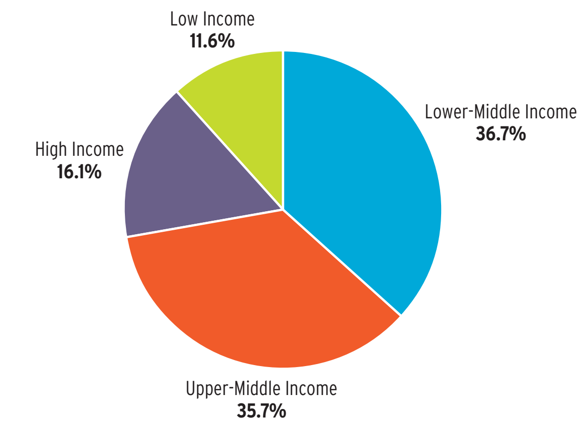
at similarly high levels of economic development. Quadrant III in Figure 23 shows the lower-intensity cities where well-being has been decoupled from emissions.

However, certain Quadrant II cities with high greenhouse gas emissions and high GDP per capita also have economies with low greenhouse gas intensity (Figure 25). This can be explained by the fact that GDP growth in low-intensity developed cities far outstrips population growth. For example, in Chicago, New York, and Los Angeles, the ratios of GDP growth rate to population growth rate are 3.38, 3.33, and 2.67, respectively. London's GDP growth rate is 105 times the rate of its population growth.

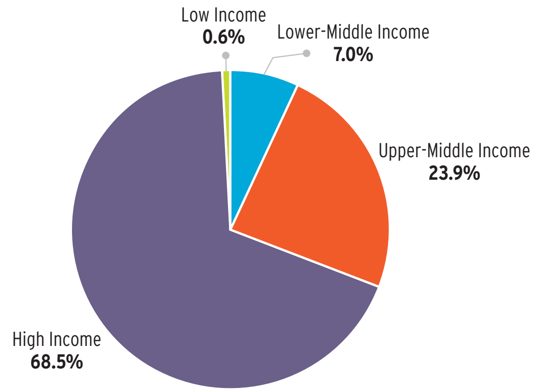
On the other hand, in the developing cities with high greenhouse gas intensity, the population growth is similar to or even greater than GDP growth in some cases. In Beijing, Shanghai, and Lagos, the ratio of GDP growth to population growth is 1.01, 1.04, and 2.1, respectively. Kinshasa's GDP is growing only 81 percent as fast as its population. Hence, the discrepancy between high greenhouse gas intensity and low GDP per capita stems, at least in part, from the fact that as developing city economies grow, their de-carbonization occurs more slowly than the rate at which their populations grow.

Decoupling urban growth from emissions may be most important in middle-income countries. As noted above, Quadrant I contains several fast-growing middle-income cities. Figure 26 shows that while high-income countries account for 70 percent of the world's GDP, they actually produce only 39 percent of the world's greenhouse gas emissions. This relationship is reversed for the upper-middle-income countries, which account

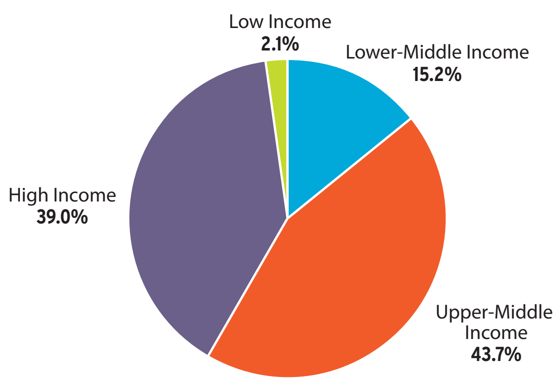
FIG. 26
GDP and Greenhouse Gas Emissions by Country Income



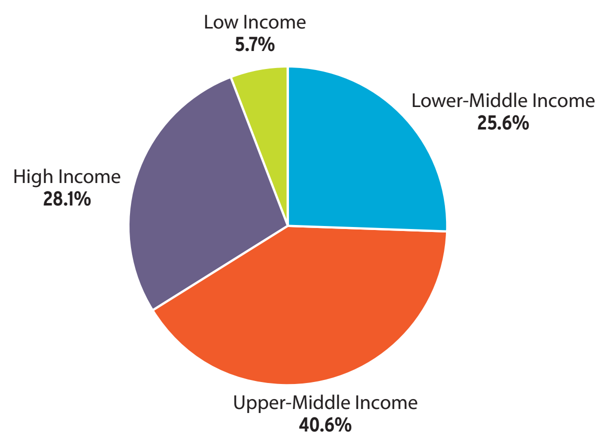
a. Share of Total World Population (6.9 billion in 2010), Percent



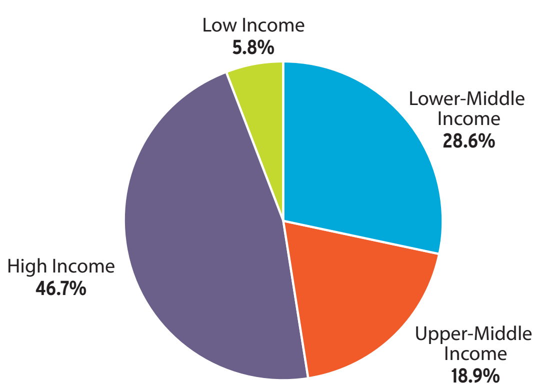
b. Share of Total World GDP (US$63.3 trillion in 2010), Percent



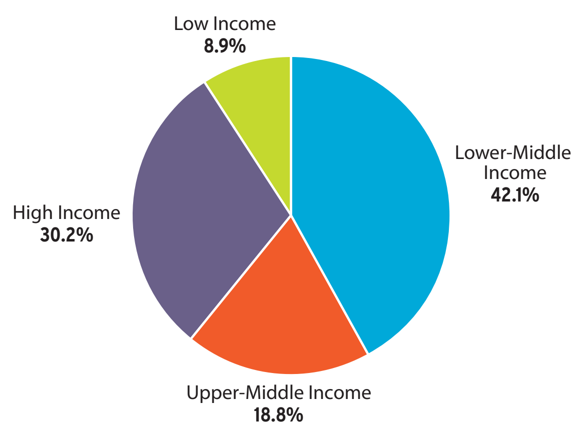
c. Share of Total World GHG Emissions (40.5 billion tCO2e in 2008), Percent



d. Share of Total World Population in Cities with 1 Million or More Residents (1.3 billion in 2010), Percent



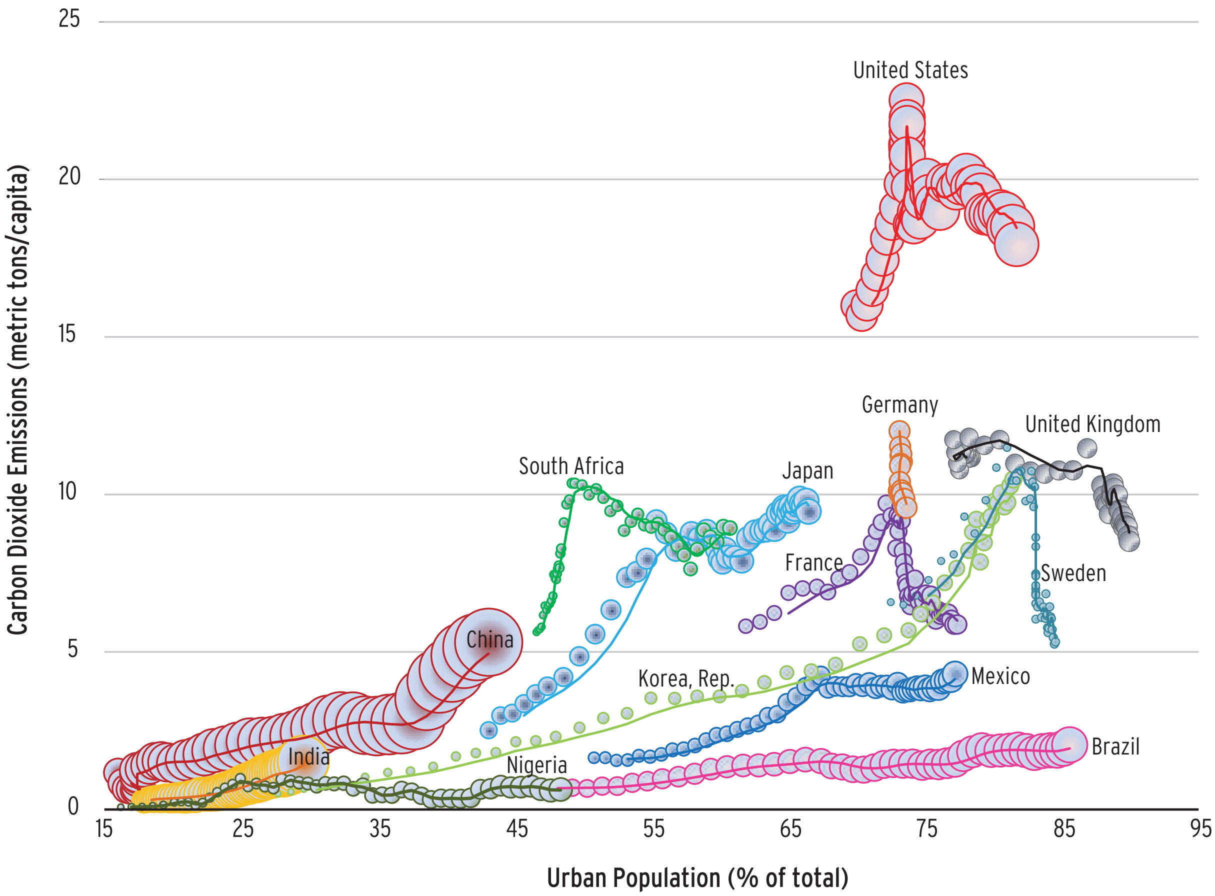
e. Share of Total Municipal Solid Waste Generation (1,289 Mtonnes in 2010), Percent



f. Share of Total Municipal Solid Waste Generation (2,269 Mtonnes projected in 2025), Percent

Source: Hoornweg and Bhada-Tata 2012.

FIG. 27
Carbon Dioxide Emissions versus Urbanization (1960–2008)



Source: Author's calculations, see data in Annex 10.

for only 24 percent of the world's total GDP but emit 44 percent of total greenhouse gases. Greater carbon efficiency can and should be pursued as these economies continue to grow.

Figure 27 shows another simple analysis of urban sustainability based on a different pair of indicators—in this case, the per capita emissions of countries versus their level of urbanization. Some interesting patterns appear; Brazil, for example, has the greatest rate of urbanization but relatively low emissions growth. Overall, the trend is consistent with previous analysis:: public policies play a large role in decreasing carbon intensity.

Other frameworks can also be used to understand differences among cities. For instance, Bai and Imura (2000) compare East Asian cities by describing four sequential stages in the evolving urban environment: the poverty stage, the industrial pollution stage, the mass consumption stage, and the eco-city stage. The authors argue that for a particular city at a given time, environmental issues related to poverty, production or consumption gain dominance, until another group of issues becomes prominent in the succeeding stage of development. The eco-city stage assumes that as the level of economic development increases, citizens will adopt more resource-efficient lifestyles and develop greater environmental consciousness. For the 100 urban areas that we have examined, this stage may be represented best by Quadrant III cities.

Analyses and categorizations such as these can be made more comprehensive and accurate as urban data collection becomes more institutionalized and more standardized. Given the wealth of information that has been extracted here with even an extremely limited dataset, the Large Urban Areas Compendium can be expected to contribute even more to efforts at understanding the drivers of sustainability and developing a broader and deeper typology of sustainable cities.

The Case for an Urban Resilience Index

Efficiency and pollution are not the only factors that need to be monitored and managed in a sustainable city. As adaptation becomes more important in fast-growing and vulnerable cities of the developing world, tools designed to assess environmental quality should be expanded to measure how prepared these cities are for climate change.

While the consequences of climate change are increasingly evident in cities across the world, the process of assessing and forecasting the risks for an individual urban area is complex and accompanied by considerable uncertainty (Box 36). Box 37, lists some of the most vulnerable cities, based on multiple different ranking studies. As yet, however, there is no reliable, internationally accepted common metric that would establish which cities are most at risk and enable governments to track progress toward urban resilience and adaptation.

An integrated urban risk metric would standardize the procedures, requirements, and steps to measure hazard, exposure, vulnerability, and adaptive capacity, as well as the economic valuation of projected damages and losses. Such standardized

Photo: Julianne Baker Gallegos/World Bank

BOX 36

Forecasting Climate Hazards

While certain types of hazards, such as earthquakes, can be forecasted with some accuracy—at least in terms of location, if not of timing—others are even more difficult to forecast. For instance, sea-level rise occurs at different rates in different parts of the globe and is highly dependent on, among other things, how much and how fast the Arctic and Greenland ice caps melt. The frequency and intensity of high-precipitation events, which increasingly are triggering devastating floods in many cities, can be predicted from global climate models via downscaling techniques, but generally with significant uncertainty.

steps would also specify the probabilistic risk assessment and climate change downscaling techniques to be applied. When such a metric is established and widely adopted, it will help to focus the attention of local, national, and international policy makers on urban risks, presumably triggering more preemptive action and greater financing.

Urban risk and resilience are complex and multi-dimensional, and it has proven extremely difficult thus far to reduce these issues to a few indicators—and, by extension, to an aggregate index that can provide a comprehensive assessment of resilience. One major effort by the World Bank to address this gap has been the development of the Urban Risk Assessment methodology (Box 38). However, Urban Risk Assessment is an approach for the detailed specification of where and how many people are vulnerable to natural hazards, and identification of susceptible urban infrastructure. It does not generate a comparable, standardized index that condenses the multiple dimensions of disaster and climate risk and resilience.

The Large Urban Areas Compendium presented above will contribute to the development of a comprehensive urban resilience index. Eventually, robust analytics can be carried out to arrive at a typology of urban risk that would enable comparisons across different cities. Such a typology would be useful in prioritizing the optimal types of interventions according to city type. However, as with typologies along the other dimensions of sustainability, any initiative to develop an urban resilience typology will be fruitful only if data is collected and updated on a regular basis.

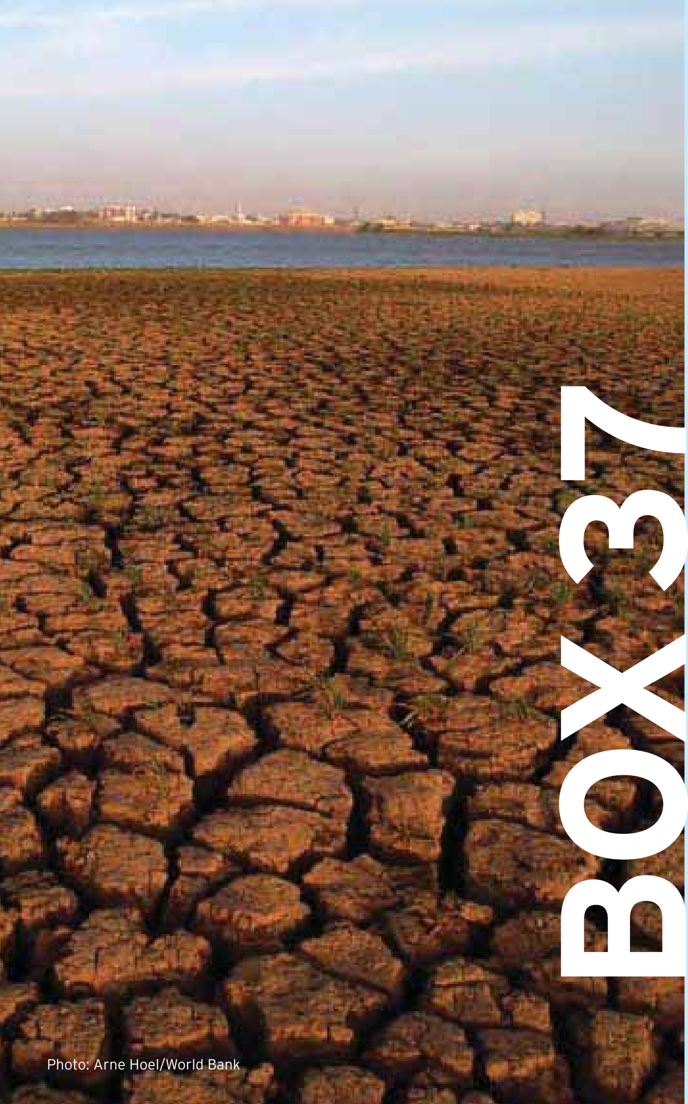


Photo: Arne Hoel/World Bank

BOX 37

Which Cities are Most at Risk from Climate Change?

Various in-depth studies over the past decade have assessed the climate-related risks facing individual cities worldwide, and some global assessments have provided overviews of urban risk across multiple cities. As each of these reviews uses a different methodology, the results are difficult to compare. In addition, some have focused on the risk to resident populations, others on the risk to economic assets. Nevertheless, to gain a broad idea of the cities most at risk, members of the Partnership for Sustainable cities compared the results of multiple global rankings of cities (Annex 12), each conducted according to its own criteria. The top 10 cities appearing in these rankings were:

- Dhaka
- Beijing
- Chittagong
- Istanbul
- Jakarta
- Kolkata
- Manila
- Mexico City
- Mumbai
- Shanghai

While this list should be considered provisional for the methodological reasons just described, it can help focus the attention of local, national and international policy makers on the urgent need to address risks in these cities. In general the cities considered most at risk are located in Southeast Asia. Among the top 10, the only non-Asian city is Mexico City.

BOX 38

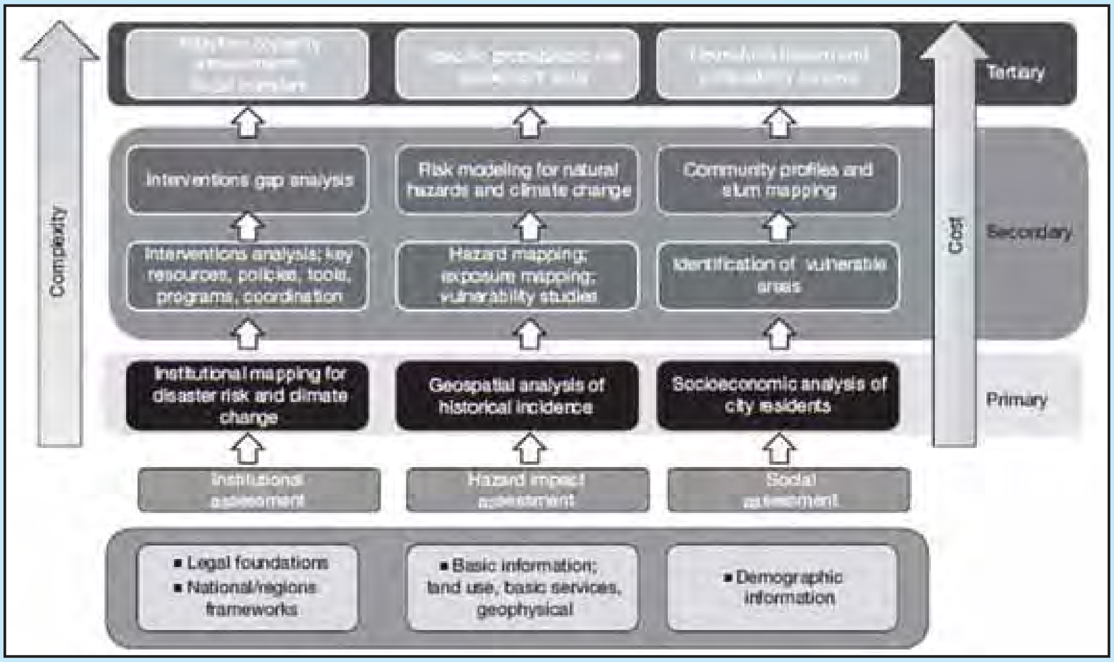
Urban Risk Assessment

To date the predominant response to disasters, both within city governments and international agencies, has largely been reactive. Given the significant impact that natural hazards and climate change will have on urban investments, increasing priority should be placed on proactive, adaptive planning to reduce and manage the potential for disasters and climate change. With this recognition, the value of identifying, diagnosing and mapping high risk areas is gaining visibility and importance. This has resulted in a proliferation of city risk and hazard assessments without a common approach. The Urban Risk Assessment (URA) seeks to strengthen coherence and consensus, minimize duplicative efforts, and bring convergence to related work undertaken across the World Bank and key partner organizations. The objective is to move towards a common cost-effective approach for specifying where and how many people are vulnerable to natural hazards, in addition to identifying susceptible infrastructure that, if damaged, would have knock-on detrimental effects on the urban population.

An ancillary objective of the URA is to better position cities to absorb and allocate discrete adaptation funds (should they be available). There are no direct linkages between city level actions and National Adaptation Programs of Action (NAPA), and no funding schemes in place to finance their implementation. When compared to other sectors such as forestry or agriculture that have typically received sizeable allocations for climate adaptation funding, cities have lacked necessary mechanisms and tools to begin sustainably addressing climate change and disaster management.

The URA is based upon four principal building blocks to improve the understanding of urban risk: historical incidence of hazards, geospatial data, institutional mapping, and community participation. The URA is structured to allow flexibility in how it is applied, depending on available resources and institutional capacity of a given city. Through a phased approach linked to complexity and required investment, city managers may select a series of subcomponents from each building block that individually and collectively enhance the understanding of urban risk.

The URA lays the groundwork for the definition of a plan for strategic collaboration across city governments, the private sector and development agencies to begin benchmarking their own progress towards the reduction of urban vulnerability.



Source: Reprinted from World Bank (2012b).

What Should a Resilience Metric Include?

In order to be comprehensive, any urban resilience metric or index would primarily need to integrate natural disaster and climate risks. It needs to recognize the full extent of certain climate impacts that occur over large areas and accumulate over time. These can be in the form of large numbers of widespread but localized disasters (associated with sea level rise, drought, and flooding due to storm surges, for example). While possibly accounting for only a small proportion of overall disaster mortality in comparison to geophysical hazards like earthquakes, extensive climate risks can significantly damage housing and local infrastructure, particularly in low-income communities. Furthermore, in addition to the hazards directly threatening a city, those that may affect it indirectly—such as the future yield of rural watersheds from which cities draws water resources—need to be part of the assessment of urban risk.

To present a complete picture of risk, an urban resilience index must address the exposure of both the population and economic assets. Figure 28 shows the regional distribution of the number of hazard victims as well as the shares of economic damages (2000–2010 average). For all hazard types (climatological, geophysical, hydrological, and meteorological), the vast majority of victims were in Asia. During this period, Africa accounted for 15 percent of the victims of climatological hazards (in this case, drought). However, across all types of hazards, the Americas sustained the largest share of economic damage, despite accounting for only 11 percent of the world's victims of geophysical hazards and even lower proportions for the other types. While this region has fewer people at risk, it has more economic assets.

Assessment of exposure to hazards will involve detailed data describing a city's precise elevation, geological profile, air quality, the hydrology of natural waterways and drainage systems, ecosystems, the location and characteristics of infrastructure, the utility systems, and the spatial distribution of residential, commercial and productive areas. Such analytics, generally captured in the form of GIS layers and maps, need to be accompanied by detailed assessments of the vulnerability of city assets. For instance, geological micro-zoning can assess which parts of the city are most exposed to earthquakes, but only the detailed analysis of the structural characteristics of buildings in those zones will determine their vulnerability in case of an event.

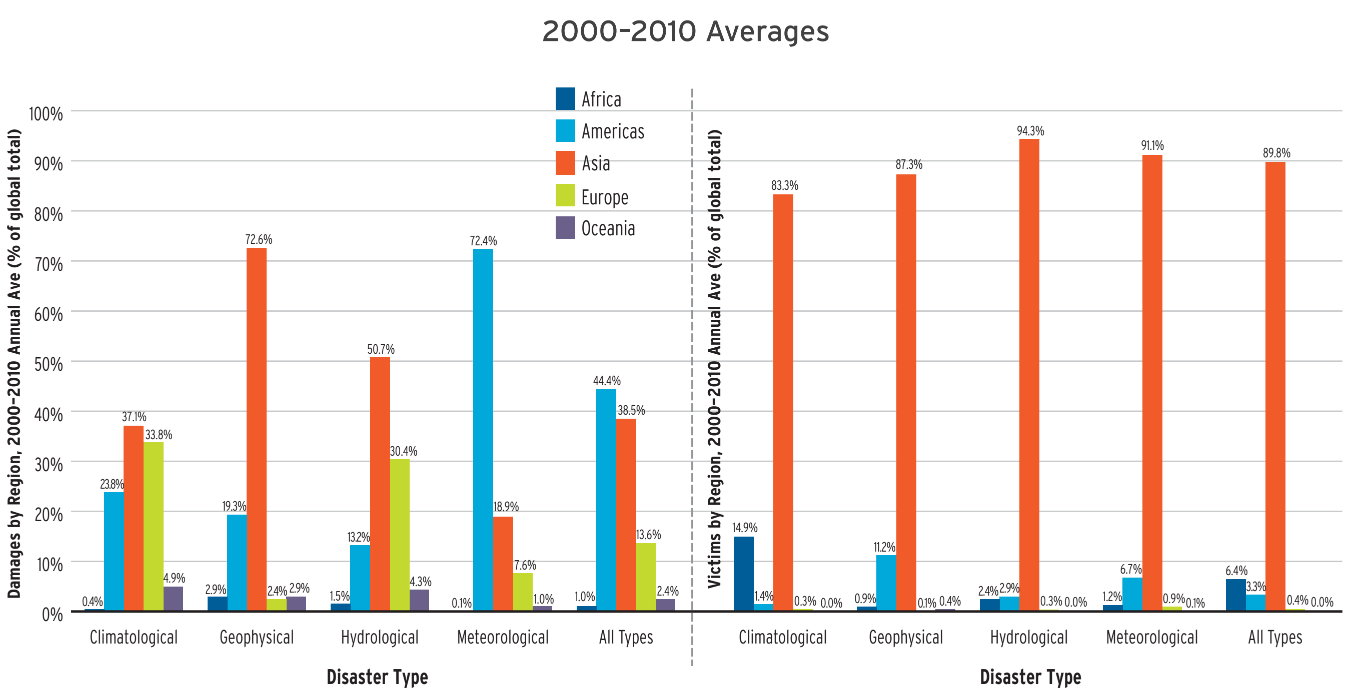


FIG. 28
Impacts of Natural Hazards by Region

Source: Adapted from Bigio 2011.

Another important component of urban risk assessment that should be integrated in a standardized urban risk metric is the economic valuation of potential damages and losses from projected natural disasters and climate change impacts. Economic valuation techniques draw from environmental economics and cost-benefit analysis methodologies to project the cumulative value over the assessment period, and calculate a net present value of the aggregated amounts based on accepted discount rates. As the damages and losses can be attributed to specific vulnerabilities and risks, the costs of mitigation or remedial actions can be calculated. This will help policy makers understand which measures are most cost-effective and will provide a return (in terms of avoided damages and losses) greater than their costs. However, as with urban resilience metrics in general, a standardized methodology for economic valuation has not yet been established.

Finally, risk management mechanisms have to be assessed. This entails a review of the technical and governance measures that sub-national or national government agencies have taken or can take to address the risks identified through the previous steps. Such measures include setting up and managing early warning systems, improving hazard forecasting capabilities and public information systems, educating and mobilizing citizens via community emergency plans, coordinating emergency responses across institutions, and mobilizing of technical and financial capabilities for urban resilience and adaptation. All these contribute to the adaptive capacity of the city.

While scientific analysis can measure hazards, exposure and vulnerability (albeit with various degrees of uncertainty), the adaptive capacity of a given city and its institutions will be assessed mostly through qualitative evaluations of the response mechanisms. The results are likely to be based on expert judgment rather than solely on data-driven indicators. There are, of course, established methods for such adaptive capacity assessments, but their conclusions are very much related to the institutional and cultural context in which they are carried out. The comparison of adaptive capacity across a number of cities via a common metric raises methodological issues that have not yet been resolved.

At the Partnership Toward Sustainable Cities workshop (June 2011), 70 representatives from NGOs, corporations, government agencies, and universities described more than two dozen comparative urban tools. These included systems for gathering and classifying data, indicators, indices and rating schemes, analytical frameworks for measuring urban characteristics and impacts, communication tools for presenting complex datasets and analyses, and funding and development strategies.

Further Reading

Annex 2 describes Siemens' Green City Index series in detail.

Annex 3 gives additional background on the GCIF.

Annex 7 outlines the data needed for an abbreviated urban metabolism study, designed for cities with limited resources or institutional capacity.

Annex 8 diagrams the metabolic flows of cities.

Annex 9 lists the 100 cities used for the initial release of the Large Urban Areas Compendium, and for the city typology discussed above.

Annex 10 shows examples of Large Urban Areas Compendium data from three cities.

Annex 11 applies a multi-hazard risk assessment the 100 largest urban areas.

Annex 12 reviews existing rankings of the world's most at-risk cities.

Annex 18 details the urban data that Earth observation satellites can provide, and its uses in planning and disaster risk management.

PART III
The Role of Institutions and Partnerships

Photo: Curt Carnemark/World Bank

6 Governance and Implementation

Key Messages

- **Strong institutions and partnerships among the public sector, private sector and civil society are needed in order to adopt multi-sectoral policies for sustainable, green urban growth.**

- **Capacity-building in local governments and enabling policies at the national level are both important to support sustainable cities.**

- **Public-private partnerships are opening the provision of public services to the private sector. However, the public authority must create the enabling policy environment and a regulatory framework that protects the interests of both citizens and investors.**

- **Transnational municipal networks allow cities around the world to collaborate on innovative approaches for urban sustainability. Agreements among cities can circumvent deadlocked international policy negotiations.**

- **Civil society is emerging as a key stakeholder in implementing participatory processes in urban governance. At the same time, information and communications technology is opening vast new horizons for public participation.**

- **Despite the existence of a wide array of options for making urban systems sustainable—but ideas, tools, and metrics do not create sustainable cities by themselves. The key to changing the situation on the ground is institutions and their interactions (see Box 39).**

Photo: 123RF

BOX 39

Case Study: Institutions and Adaptation in Louisiana and the Netherlands

Louisiana and the Netherlands had very different reactions to local rises in sea level during the 20th century, and the contrast shows the importance of institutions in adapting to the impacts of climate change. In the case of Louisiana, risks were addressed ex post, with levees being reinforced only after disasters had occurred. In the Netherlands, on the other hand, the Delta Commission institutionalized risk management by reinforcing the seawalls on a regular basis, among other measures. Thus, the Netherlands' successful strategy since 1953 is arguably due more to institutions like the Delta Commission than to physical protections such as seawalls.

These institutions can belong to the public sector (international agencies, bureaucratic line agencies, elected local government units), the private sector (businesses, developers, investors), or civil society (transnational municipal networks, NGOs). The issues facing cities span all these sectors, and multi-sectoral policies are needed. For such policies to be successful, cities have to embrace broad participation in decision making and use reliable institutions or partnerships for implementation (Box 40).

For example, land use, urban form, and urban planning are critical to transport-related energy consumption and for adaptation planning. However, institutions often have trouble carrying out the design and enforcement of urban plans and can sometimes face resistance from citizens, which can only be dealt with through open and integrated consultative processes. Institutional weaknesses, such as inadequate land tenure, often make it harder to implement and enforce strategic land-use plans. Consequently, the first step in the design of sustainability policies is to review institutional capacity, identify institutional obstacles, and build a strategy around these limitations. Below the roles and needs of different types of institutions are considered in urban sustainability initiatives.

BOX 40

Governing the Twenty-First Century City

Whether in the developed or developing world, cities face many similar challenges: concentrations of poverty and unemployment, environmental degradation, lack of public safety, and political corruption are only some of the most significant. In "Governing the Twenty First-Century City," Fuchs (2012) argues that the most effective way to address these policy challenges is to strengthen urban governance and institutions.

- A fair governance structure, with sufficient fiscal and administrative autonomy, is needed to efficiently and equitably deliver public services that support an environmentally sustainable economy.
- A clear link between city institutions and the delivery of public services ensures the legitimacy and authority of local government, thereby promoting security and public safety.
- Strong democratic institutions of local governance and high levels of political participation enable clear accountability when cities (as opposed to national or state governments) are the entities that have a legal responsibility, fiscal capacity, and administrative authority to deliver public services.
- Service delivery can be contracted to the private sector or to NGOs, but the local government must still have the expertise and fiscal capacity to provide oversight and be accountable to civil society.
- City governments must have the capacity and autonomy to build partnerships with businesses, community groups, and other government entities, and provide incentives that promote entrepreneurship, encourage businesses to locate in the city, and drive job growth.
- The leadership of the city government is necessary for the clearly linked, systematic long-term planning required for infrastructure investments, quality-of-life initiatives, ease of doing business, and environmental sustainability.

Local Government

Local governments are critical to urban sustainability through their roles in development planning, in the delivery of basic social services, and in energy supply and management, transport, land-use planning, and waste management. Local governments can fulfill these roles only if they have sufficient governance capacity. Bulkeley et al. (2011) list critical factors in building governance capacity, including access to financing, municipal competencies, the multi-level governance framework, and transnational networks. Data and expertise at the local level are also necessary to provide a base for integrated, multi-sectoral planning—as seen, for example, in New York City's PlaNYC.[26]

Knowledge and capacity related to urban sustainability may be institutionalized in special units established in the mayoral office (such as New York's Office of Long-term Planning and Sustainability), or in a special municipal agency (such as Curitiba's planning agency, Instituto de Pesquisa e Planejamento Urbano da Curitiba[27]). These bodies are effective because they are capable of providing high-level technical and analytical inputs to urban planning, they have long-term, continuous mandates and organizational structures, they are afforded relative autonomy, and there are mechanisms for public participation in the development and implementation of sustainability plans.

Pro-poor adaptation to the impacts of climate change is one area where, in general, city and municipal governments need greater capacity. Improved knowledge, competence, and accountability would increase the adaptive capacity of local bodies. One successful example is Porto Alegre, Brazil, where resilient urban development is evident in environmental and social programs, coupled with a strengthened local democracy and reduced anti-poor attitudes (Sattherthwaite et al. 2009).

As discussed in Chapter 4, it can be particularly challenging for cities to address climate-related risks to poor and vulnerable populations. These groups tend to live in informal settlements with insecure land tenure and little urban infrastructure, and work in the informal sector with no safety nets. Natural disasters compound risk to these communities and can foster poverty traps. While land tenure and informality are still issues cities grapple with globally, implementing policies that build resilience in low-income neighborhoods and slums help control the risk of disasters. Enacting these policies requires coordination among departments at the municipal level, and with civil society and private sector partners.

The transition toward sustainable cities will also require significant investments, which means that new institutions and financial instruments will be needed. Many possible instruments have been discussed at the international, national, and even local scale. They include access to carbon finance and carbon markets (Kamal-Chaoui and Robert 2009), specialized climate or environmental funds, socially responsible investment (Labatt and White 2007), or subsidized access to capital. In addition, the worldwide trend of government decentralization has given many cities more power to raise and manage their own revenues (Box 41).

Because of limited financial resources, many municipalities in developing countries still have difficulty providing even basic services, particularly to the urban poor. From both a political and budgetary standpoint, this can place a low priority on investments to address longer-term sustainability issues. The framework of green growth may convince city actors to see sustainability investments as an economic opportunity, but access to financing will be crucial to this mainstreaming.

[26]http://www.nyc.gov/html/planyc2030/html/home/home.shtml
[27]http://www.ippuc.org.br/default.php

National Government

Innovations at the city level require appropriate national policies. An enabling national policy environment allows cities to experiment and be creative. For example, London was able to innovate in designing and implementing its congestion charge because the national government allowed and encouraged such experimentation.

The role of cities goes beyond the cities themselves, given their importance to prosperity and growth. Urbanization increases in lock step with economic development, and the ability of cities to remain attractive and efficient is crucial to secure and sustain national growth. Thus, national governments have a strong economic interest in urban sustainability, and they should take the lead on the coordinated design and implementation of enabling policy instruments. National leadership helps to harmonize different goals and programs, and provides scalability so that cities can exploit the most cost-effective opportunities.

Public-Private Partnerships

To move toward sustainability, cities must transform the processes of production and consumption—and businesses are often at the heart of these processes (Box 42). Moreover, since the mid-1980s, there has been a global trend of opening the provision of public services to the private sector (World Bank 2004; see Annex 14 for examples of pilot projects). These services are no longer seen only as public goods, but also as economic services.

BOX 41

Decentralization of Governance

In recent decades, many countries have decentralized their governments to a greater or lesser extent (World Bank 2008). Decentralization shifts authority, responsibility, and accountability for public functions from the national government to local governments (Republic of the Philippines 1991). Hence, municipalities usually have the power to create and broaden their own sources of revenue, in addition to receiving a share of national revenues and proceeds from the utilization of natural resources within their jurisdiction.

The most empowering forms of decentralization, however, provide the political space for local government action. They also allow the private sector to participate in local governance, particularly in the delivery of basic services and infrastructure, as an alternative strategy for sustainable development.

With decentralization comes a transfer of authority for planning, finance, and management to units of local government. Responsibilities for service provision rest with local governments that raise their own revenues and have independent authority to make investment decisions. However, in many developing-country municipalities, the tax base is so weak that dependence on central government subsidies still persists. For fiscally decentralized cities, authorization of municipal borrowing is emerging as an important channel through which cities can access financing for investments that contribute to their sustainability agenda (Kamal-Chaoui and Robert 2009).

Vision 2050: The New Agenda for Business

BOX 42

The WBCSD's Vision 2050 calls for a new agenda for business that is compatible with good living standards and sustainable resource use. As part of the project, 29 global companies mapped the changes necessary to create a sustainable future. The outcome was the result of 18 months of expert meetings, and dialogues with more than 200 companies and stakeholders in 20 countries.

The results of this work provide a strategic framework for navigating the many challenges ahead, along with a platform for dialogue for governments, businesses, and other stakeholders. One of the conclusions is that to achieve sustainability, the world will need to transform the processes of production and consumption and this will require building complex coalitions among stakeholders in order to create new sustainable solutions.

The must-haves (what society and corporations need to do) include incorporating the costs of externalities, starting with carbon, ecosystem services, and water; halting deforestation and increasing yields from planted forests; halving carbon emissions worldwide (based on 2005 levels) by 2050 through a shift to low-carbon energy systems; and improving demand-side energy efficiency and providing universal access to low-carbon mobility. At the same time, these changes will offer great opportunities. From the actions to develop and maintain low-carbon and zero-waste cities, to improving biocapacity and ecosystems, the business potential is estimated at $3–10 trillion per year (current dollars).

Source: Adapted from http://www.wbcsd.org/vision2050.aspx.

Photo: Shutterstock

Telecommunications has garnered the most corporate interest, accounting for 53 percent of total investments with private sector participation from 1990 to 2001. Other sectors that have benefited from private investment are energy (32 percent), transport (18 percent), and water (5 percent) (World Bank 2001). Today, many municipal services are operated by the private sector, in the form of public-private partnerships (Table 7). Even smaller services that used to be publicly controlled, such as markets and bus terminals, are now often transferred to private operators.

TABLE 7
Examples of Private Participation in Public Services

	Waste	Water	Wastewater	Transport
Paris	Storage and treatment: some facilities operated by the private sector (Generis, Paprec, Nicollin, REP, Novergie, SITA, etc.) MSW collection: one part operated by the private sector (Veolia Proprete, Derichebourg Environnement Polyurbaine, Pizzorno-Dragui) Glass collection: Four companies under contract (Polyurbaine, Pizzorno, Sepur, Sita)	Distribution: beginning in the 1980s two service areas split between Suez and Generale des Eaux (Vivendi) Pumping: Eau de Paris (public company with participation from Paris)	None identified	Metro, tramway and buses operated by RATP (public company)
Mexico City		Distribution contracted in 1993 to four companies that share the city. The companies are consortiums of Mexican companies, Mexican banks, and foreign companies (Suez, Generale des Eaux, Severn Trent, North West Water International).	The construction of six new treatment plants is expected to be financed by the private sector through build-operate-transfer projects. In 2011, Acciona was awarded the contract for the largest plant.	Individual owner-operators of small buses Sistema de Transporte Collectivo (public company) manages the metro Red de Transporte de Pasajeros operates the bus network Metrobús is jointly operated by Corredor Insurgentes, SA de CV, a private company, and Red de Transporte de Pasajeros
Lagos	Collection: about half contracted to private-sector partnership operators, including street sweepers Informal sector also active Billing and collection of fees: contracted to a private firm (World Bank 2006)	None identified	Development of public-private partnerships for the implementation of the Sustainable Sewage Sanitation Strategy	Multiple private operators of mini-buses LAGBUS privately operated Ongoing privatization of ferries Commuters-to-be expected to be privately operated

The advantages of private sector provision of public services, compared to publicly owned utilities, can include the following:

- *Improved management efficiency:* Public administration is not usually guided by profitability and can have conflicting objectives—such as generating employment—that reduce economic efficiency. The private sector is driven by financial results and is committed to reducing costs, increasing bill collection, and adjusting prices for improved profitability. In many examples of private sector provision, billing rates increase significantly. However, cost cutting may entail a risk of lower safety and security of supply.

- *Extended and improved service provision:* The entry of the private sector has also resulted in better service quality—such as increased operation time and better reliability—and increased access, especially in developing countries. The mobile phone market took off in Uganda after CelTel entered in 1995; access reached 15 percent in only six years. In the water and electricity sectors, the trend is similar. However, privately operated service does not guarantee improved service, and in some cases the service quality actually decreases.

- *Infrastructure financing:* The multiple systems of urban infrastructure require high capital investment and operating budgets that local governments alone cannot provide. Private investment is needed to complement public funding of infrastructure. Public-private partnerships such as the Chicago Infrastructure Trust (Box 43) can attract and coordinate this finance. In regions facing rapid urbanization and very large infrastructure gaps, such partnerships can play an even more critical role in financing construction to meet the increasing demand.

- *Innovation:* Competition for private participation in publics services and the prospect of profits have driven innovation in production and distribution technologies as well as in service management. Kessides (World Bank 2004a) suggests that "decentralized, market-oriented decision making freed from excessive regulation and energized by market incentives is the surest way to develop efficient, innovative solutions to transportation challenges." In the water sector in South Africa, Durban Metro Water partnered with Generale des Eaux and Vivendi to design and test schemes to provide free water to the poorest, as mandated by law, while avoiding a financial burden on paying customers.

In developing countries, the private sector also supplies public services that local authorities fail to deliver. In some peri-urban areas (usually poor neighborhoods), small, privately owned operators take the place of the public sector and operate essential services such as water supply or electricity. For example, in Cebu, the Philippines, 50 percent of the population receives water from independent suppliers who pump water from private wells. Those businesses may be run in an informal market when the regulatory framework is weak or inappropriate.

Where public-private partnerships are used to provide services, private companies will be among the key institutions for adopting efficient and low-carbon systems. In the field of adaptation to climate change as well, there are good examples of collaboration between cities and the private sector. In Barranquilla, Colombia, for instance, the company Sociedad Acueducto extended water and sewage services to reach 350,000 low-income inhabitants by issuing a long-term local currency bond of $63 million to refinance its debt. In Kuala Lumpur, Malaysia, a joint venture between the Malaysian Mining Corporation Berhad, Gamuda Berhad, and the government to develop a dual-purpose tunnel that carries both vehicular traffic and stormwater has reduced adverse economic impacts of traffic congestion and recurring floods (World Bank 2011a).

BOX 43

Case Study: The Chicago Infrastructure Trust

The construction, operation, and renovation of infrastructure are complex and costly endeavors that require a wide array of stakeholders to contribute their capital, expertise, and particular vision. The budget constraints of many governments have added a further dimension of difficulty, in that cities can no longer depend upon infrastructure funding streams from higher levels of government. In these circumstances, even projects with high payback potential (for example, energy efficiency) are unlikely to be realized without extensive collaboration between public and private entities. With more actors representing various priorities and resources, however, it falls upon the city or metropolitan government to play the part of the maestro in the urban infrastructure orchestra.

One promising example can be seen in Chicago Mayor Rahm Emmanuel's recent creation of a public-private infrastructure bank—the Chicago Infrastructure Trust—that will act as the centerpiece of the city's ambitious $7.2 billion infrastructure plan. The plan sets out an entire sustainable development agenda, and the first challenge to be tackled by the trust will be the $200–225 million city building retrofit effort, slated to reduce energy consumption by 25 percent and save the city $20 million per year.

Five of the world's leading infrastructure investors—Citibank, Citi Infrastructure Investors, Macquarie, J.P. Morgan, and Ullico—have announced their intention to work with the trust. One of the first steps for the five mayor-appointed members of the trust's governing board will be the establishment of a clear methodology for prioritizing projects. It is crucial that, in the initial phases of the program, projects be assessed on a case-by-case basis. Chicago proposes that each deal in its trust be structured as a stand-alone limited liability corporation, thereby giving the particular characteristics of each potential project a better chance of being taken into account, and minimizing the potential risk that typically accompanies a formulaic approach.

Alongside economic and energy savings, co-benefits and well-being improvements should be targeted. For example, tax-increment financing can be used to capture returns from investments in walkable, mixed-use development.

As with most public-private partnerships, the challenge for the city is to remain in control of the public realm. In 2009, a 75-year, $1.2-billion concession of city parking meters to a private company resulted in a bevy of criticism against rising rates, fines, and the general disorder of the meters. More significantly, the city lost its authority to manage curbside space and thus risks being unable to implement transportation projects if there is the possibility that they would negatively affect the private company's parking meter revenues. In the long run, a demonstration of success by the Chicago Infrastructure Trust may prove to be a valuable input in the creation of a more programmatic approach to sustainable transport, water, and energy efficiency projects that other cities can follow. The resources and experience of a given city government will be a key driver in ensuring that power and information asymmetries between the public and private partners do not endanger the delivery of public benefit.

Chicago is not alone in this endeavor. Other sub-national institutions have begun to study how they can attract private dollars for public projects. The $233.4-billion California Public Employees' Retirement System (CALPERS), for example, is sponsoring four infrastructure roundtables to explore how best to allocate assets in U.S. infrastructure projects. Around the world, municipalities and institutional investors alike will be watching the results in Chicago. Done right, the Chicago Infrastructure Trust will not only create attractive investment opportunities, but will demonstrate that a sustainability focus is a wise down payment towards an efficient and equitable urban future.

Public-private partnerships take different forms according to the level of private sector participation. Involvement ranges across a large span of functions such as capital investment, production, distribution of service, maintenance, billing, and so on. The most common types of contracts are lease agreements, concessions, licenses, and build-operate-transfer arrangements. The choice of contract should be carefully decided based on local circumstances to avoid possible bottlenecks in service provision.

In these partnerships, the public authority has an essential role in framing private sector participation, creating competition, and enforcing good management (see Box 43). Effective regulation is the most critical condition for reform, protecting the interests of both private investors and consumers (Asian Development Bank 2008). An enabling policy environment that creates stability and mitigates the risks associated with investment is key to attracting private sector partners.

Multilateral Institutions, Municipal Networks, and Civil Society

International agencies have long recognized their mandate to provide leadership on sustainability issues, and today they increasingly understand the importance of socially inclusive, competitive cities that offer good well-being (World Bank 2009). Multilateral institutions are engaging with cities and providing tools and knowledge to deliver improved value for public spending, while promoting sustainable development.

A good example of such a program is the European Union's Reference Framework for Sustainable Cities (RFSC).[28] This is an online, operational toolkit to assist local authorities and other bodies in improving the design and promotion of sustainable development strategies and projects. Community-based organizations and the private sector can also use the RFSC as a resource when participating in urban sustainability planning and programming. The RFSC provides a multi-purpose, multi-stakeholder decision making and communication tool with a broad range of questions that can help politicians, city managers, planners, citizens, businesses, and civil society organizations to review their approaches toward sustainability. Tools are also available to monitor implementation and to evaluate results. The toolkit is open and flexible, and can be adapted to suit various political, geographic, economic, environmental, and social contexts.

Also notable among the institutions involved in action toward sustainable cities are transnational municipal networks such as C40, ICLEI, Metropolis, and UCLG. These networks are helping cities become more involved in the global climate change agenda and, more broadly, in the sustainability agenda. Networks allow for the exchange of best practices, peer-to-peer learning, and collaborative development of innovative approaches toward sustainable cities. For example, in the absence of a global climate agreement at the national level, municipal networks often allow cities to enter into "shadow" agreements (such as the Urban Environmental Accords, described in Box 44) and potentially even city-level emissions trading schemes.

At the national and local levels, the rise of civil society as an institutional sector should not be underestimated. It has provided a mechanism for individual citizens and communities to collaborate with government on the delivery of public goods and services, and advocate for accountability. NGOs, civil society organizations, and community organizations can strengthen service provision and environmental management, improve the livelihoods of communities, and even contribute to urban planning (Box 45). In many cities, civil society and community-based

[28] http://www.eumayors.eu/news_en.html?id_news=436

disaster risk management have proven to be more successful than local government interventions for building resilience to climate change. A strong evidence base is key here, as a well-informed civil society will be better able to prepare and respond to extreme weather events.

Civil society operates in the space where the private and public sectors fail to deliver services equitably. Urban sustainability will rely on governments and businesses empowering, training, and partnering with the civil society organizations that are filling these gaps.

Participation in Urban Governance

There is now a consensus that the quality of governance depends on participation and accountability (ASEAN Studies Center 2010). While the participation of citizens alone does not necessarily guarantee better governance or service provision, it helps to link leaders with stakeholders, fostering a shared vision and understanding of the necessary tools to achieve it. History and local conditions influence the mechanisms and impact of participatory processes, but in all cases, governance models are changing from traditionaltechnocratic control to participatory approaches that rely increasingly on civil society and the business community (UN-Habitat 2010b).

The process can be as simple as holding elections, consulting with grassroots organizations, or mobilizing their assistance. In the electoral sphere, a deeper modality of participation includes such tools as the ballot initiative, referenda, and recall elections. These are widespread in North America

BOX 44

Reviving the Urban Environmental Accords

In June 2005 in San Francisco, 52 city mayors from around the world gathered and signed the Urban Environmental Accords (UEA), recognizing that "cities are the main culprit of environmental degradation and have the responsibility and authority to solve consequent problems." They agreed to implement activities in environment-related sectors (for example, energy and waste management) and to evaluate cities' efforts and performance in 2012.

While the UEA has 109 signatory cities worldwide, no governing council had been held since its founding in 2005, nor has it been acknowledged as a UN-affiliated organization. To address this, the City of Gwangju, Korea, organized the 2011 UEA Gwangju Summit. Gwangju co-hosted the Summit with UNEP and the City and County of San Francisco.

The 2011 UEA Gwangju Summit was attended by a total of 822 mayors and representatives from 114 cities worldwide, as well as experts from 12 international organizations. The meeting was important in gathering city representatives and introducing the idea of an Urban Clean Development Mechanism (CDM). Major outcomes included the adoption of the "Gwangju Declaration," which advocates for an Urban Environment Evaluation Index and an Urban CDM, the establishment of the "Global Low-Carbon Green City Award" in partnership with UNEP, the agreement to hold a UEA Summit every other year, and the establishment of the UEA Secretariat in Gwangju. Additionally, Urban CDM pilot testing will be conducted in qualified UEA signatory cities.

BOX 45

Case Study: Participatory City Planning in Chhattisgarh

The 1992 amendment of the Indian constitution (74th Constitutional Amendment Act) provided for local government devolution and vested the functions of urban, economic, and social development planning with local urban bodies. However, full devolution has been slow to take place due to a lack of corresponding fiscal devolution, an institutional framework for planning, and professional staff capacity. As a result, most urban plans are still developed by the Town and Country Planning Organization (a national government agency). Furthermore, there has been limited participation in the planning processes by communities and civil society organizations. Urban planning has remained primarily a technical expert-driven process, unrelated to the capacity of the local government for implementation, and for which communities had no sense of ownership.

In recognition of this situation the Society for Participatory Research in Asia (PRIA), an Indian NGO, undertook to support participatory urban planning in the state of Chhattisgarh, focusing particularly on addressing the needs of informal communities whose settlements are typically not reflected in city plans. PRIA and its partners established urban resource centers in two towns (Rajnandgaon and Janjgir) to advocate for the needs of poor groups as well as engage with civil servants and politicians to support pro-poor, accountable governance. In the actual urban planning process, PRIA conducted several rounds of collaborative, multi-stakeholder consultation with the local government, during which (a) vision statements were developed for each city, (b) a set of projects was identified and phased for implementation, (c) the projects were integrated into the municipal budget in order to ensure financial viability without dependence on external resources, (d) area-specific urban design guidelines were prepared for informal settlements, cultural heritage areas, and so on., (e) a process was created to review and modify the plan annually, and (f) the informal sector was actively engaged in the planning process.

Several challenges were encountered during this process, including (a) the need to deal with urban departments with overlapping functions, (b) the lack of legislation to enable community and civil society collaboration, (c) the perception among local leaders and municipal officials that participatory planning indicates their failure and is a challenge to their authority, and (d) unrealistic community expectations.

The partnership approach that was initiated and developed by PRIA generated demand-based plans for the towns of Rajnandgaon and Janjgir, while at the same time ensuring feasibility of the projects by identifying and prioritizing the necessary resources. Realistic and implementable plans arose because projects were prioritized and then the urban plans were developed around these projects (as opposed to plans being the driver of project selection). In contrast to the alternative of state-led urban planning, the participatory process also built local government capacity and provided a clear link between urban planners and those that would be responsible for implementation. Notably, capacity building was also undertaken to assist local bodies to identify and raise internal revenue to fund the planned projects.

The final product of the participatory planning process was a phased implementation strategy, which included (a) an investment strategy, (b) the role of each partner in the short, medium, and long term, and (c) the project phasing strategy.

Source: Sheikh and Rao (2007).

and Japan, and are spreading into Europe and Latin America. Participatory budgeting is probably one of the most effective ways to give citizens a say in how tax revenues are allocated, and experience with this process over more than two decades in Brazil and elsewhere has produced important practical lessons. Clear guidelines may be needed on the legal and judicial frameworks that govern the tools for participation. And as more data is collected on performance and well-being in cities, this information must be readily available to all stakeholders (see Box 46).

BOX 46

Case Study: Filling the Information-Power Gap in Slums of Pune

India is home to almost 20 percent of the world's slum population, and one-third of the world's poor.[a] India's urban population is set to double in the next 25 years to 600 million, and the slum population is expected to grow even faster. The country has advanced considerably over the past two decades in its national policies and its intent to create more inclusive urban growth, but government programs still stumble at implementation because they are missing the planning practices that would empower the urban poor themselves.

When urban development policies and programs plan for the poor without involving them, slum residents continue to be marginalized and solutions crippled. Slum residents have long demonstrated their ability to organize, learn from others, contribute resources, and implement solutions. There are some exceptional examples of such initiatives in India that can serve as models for the country and region, for both state and non-state actors.

In 2008 CHF International, an international NGO, partnered with the Pune Municipal Corporation in India to implement a program called Utthan (meaning "to rise from the bottom" in Hindi) with support from the Bill and Melinda Gates Foundation. Utthan collects information on the physical and socioeconomic conditions of Pune's urban slums and uses this information to empower both residents and local government officials to undertake community development projects.

The Utthan program is distinct because data is being collected by an extensive network of over 1,000 volunteers who reside in the slum communities. Rather than simply extracting this survey information for municipal planning purposes, the program gives the information about the community back to the volunteers. CHF International has trained the volunteers to organize community meetings, prioritize their development interests, and mobilize community and government resources to take action.

To date, the volunteers have collected detailed surveys in 360 of Pune's 477 slums, covering 86,000 households (approximately 430,000 residents). Over a two-year period, 130 slums have participated in this "micro-planning" process, and all of them have mobilized community improvements, both large and small, covering physical improvements, social issues, and livelihoods. The surveyed information is also aggregated into a GIS model within the local government to inform planning of service delivery.

This program demonstrates a powerful model for institutionalizing more inclusive planning in slums and empowering slum residents to create change. It also embodies some of the emerging concepts and approaches of *open development*, which the World Bank has promoted—namely, more open governance; citizen engagement in development; collective action by citizens; the co-creation of development solutions; and finally, open data, open knowledge, and open solutions (World Bank Institute 2011).

a. The World Bank's latest global poverty estimates calculate there are 456 million people, or about 42% of the population, living below the new international poverty line of $1.25 per day in India. The number of Indian poor constitutes 33% of the global poor, which is estimated at 1.4 billion people. Moreover, India has 828 million people, or 75.6% of the population living below $2 per day; Sub-Saharan Africa, considered the world's poorest region, is better off in this respect, with 72.2% of its population (551 million) people below the $2-per-day level (Chen and Ravallion 2008).

BOX 47

Mobile Phones Sweep Asia

Asia is the leading region in terms of mobile phone accessibility. Inexpensive phones are already available to some 1.75 billion people on the continent (about half the population) according to Business Monitor International. Third-generation (3G) mobile data service, which allows greater bandwidth for applications such as streaming video, is growing rapidly as well, with 200 million phones having come online as of 2010.

Mobile Penetration in Asia, 2005–2010 (Selected Countries)

	Mobile Penetration, 2005 (%)	BMI Forecast Mobile Penetration, 2010 (%)	Forecast Average Annual Growth (%)	BMI Forecast No. of 3G Subscribers, 2010 (millions)
Hong Kong	118.5	111.9	-0.3	4
Singapore	97.7	100.7	2.1	1.13
Australia	96.1	100.6	2.0	5.2
Taiwan	92.4	92.6	1.3	6.8
Korea	79.1	85.9	2.1	27.3
Malaysia	74.1	91.2	5.8	2.5
Japan	70.3	85.6	4.2	88
Thailand	46.9	78.5	14.4	5.54
Philippines	42.7	75.2	16.9	5.7
China	30.2	58.9	21.9	136.2
Indonesia	22.3	41.5	19.5	2.78
Pakistan	14.1	37.7	38.5	.9
Vietnam	10.3	35.9	62.3	2.1
India	7.0	32.8	80.1	24

Source: Business Monitor International.

Participation through Information Technology and Social Media

The availability of technology—especially mobile telecommunications, the Internet, and social media—has greatly changed the possibilities for citizen participation (Annex 13). Mobile phones are becoming more and more ubiquitous as their price continues to drop (Box 47), and the use of social media is likewise spreading rapidly.

Unlike traditional media, which simply provides a channel for mass *dissemination*, social media allows for mass *collaboration* by enabling many-to-many connectivity on a scale we have never seen before. Many see the shift toward collaborative problem-solving as not only good but necessary for the complex challenges our societies face today. Nowhere is this more essential than in efforts toward sustainable cities, which require not just improved infrastructure and regulations, but also fundamental changes in behavior. Smart cities are of limited value without smart citizens.

Large-scale collaboration is needed among governments, the private sector, academia, civil society,

FIG. 29 Social Media's Impact on Collective Action

Facilitating Collaboration on a Much Larger Scale	Empowering Individuals	Enabling Real-Time Collective Intelligence
Social media virtually eliminates communication and coordination costs, making it far easier to exchange information, to make group decisions on a large scale, and to integrate individual contributions into a collective solution.	Technological progress has empowered individuals with the capacity to do what previously required large, well-resourced organizations. Podcasts, for instance, require no expensive broadcasting licenses or professional studios—a laptop will do. In this newly flattened world, meritocracy rules as institutional advantages erode.	Social media and the move towards "open data" enable stakeholders to share information with one another at unprecedented speed and scale. Indeed, mobile-equipped citizens can today complement vast arrays of digital sensors for real-time information flows and full situational awareness.

and the public. Social media facilitates that collaboration by lowering costs, empowering individuals and providing access to unprecedented amounts of information (Figure 30). As a result, collective action is increasingly taking the form of self-organized networks that use social media for peer-to-peer decision making in place of top-down leadership and coordination. Governments and international organizations are starting to adapt to this new reality by experimenting with new models that tap into these networks.

At a more basic level, networked technologies are being used in developing countries to support traditional service provision and facilitate interactions among citizens, governments and businesses. For example, Malaysia's Government Multipurpose Card (MYKAD) serves as a common currency in electronic interactions at several levels of government (UN-Habitat 2010b), and India has recently supplied some 40 million tablets in rural areas to support education and health programs. A recent survey in India suggests that even in rural areas with particularly weak Internet service, citizens express a willingness to pay for better e-government (Kalsi et al. 2009).

Technology is also enabling greater participation and accountability. The MapKibera.Org project is mapping the slum settlement of Kibera in Nairobi, using an online platform managed by a community facility. Incidents like crime and fire can be reported, providing evidence for lobbying efforts to address these issues. In the United States, several Web sites allow citizens to file complaints, share information, and communicate urban service deficiencies such as power outages or damaged facilities. CityForward.Org and SeeClickFix.Org are two examples.

In developing countries, mobile phones are especially important for empowering citizens. Compared to Internet sites, phone applications can have the same or similar interactive features, but they do not require literacy. Information exchanged on mobile phones is generally anonymous, making them a potent political mobilization tool. The growth of mobile phone penetration has dramatically increased exchange between citizens and transformed the arena of political dialogue.

Besides messaging and community mobilization, cameras and other features of low-cost mobile phones open many new possibilities. One opportunity is the surveillance of public officials by mobile phone camera and video. The term "sousveillance" was coined by Steve Mann to capture the citizen-initiated reporting of wrongdoing, as well as the idea of watching from below (Mann 2005). Many NGOs have developed survey instruments based on open-source software that can be formatted and deployed on mobile phones. Epi-surveyor and Gatherdata start with a basic $40 mobile phone, making use of text message-based systems to gather and analyze real-time data on health and services such as water and electricity (Datadyne 2011).

Innovative governments have begun to use interactive communication channels to engage citizens and organizations as partners in public problem solving (see, for instance, http://www.challenge.gov). Governments are also leveraging social media to augment their capacity and improve their responsiveness via "crowdsourcing." Chicago's new Snow Portal, for example, enables citizens to claim neighborhood streets for community-led snow removal, to volunteer for a Snow Corps that helps the disadvantaged, and to share shovels and other equipment within their neighborhoods. Companies, too, have begun to realize the benefits of adopting a more open and collaborative approach, as they increasingly contribute to and launch open source projects and move toward consensus-based standards for everything from data to processes.

While these local applications of social media hold much promise, issues like climate change also call for collaboration at the global level across nations, cities, corporations, civil organizations, and ultimately individuals. Here, too, ICT and social media have a critical role to play by facilitating the intensive information flows and transparency needed for day-to-day coordination, knowledge sharing, mutual accountability, and trust. And if information networks are central for governance of sustainable development, they are equally important for sharing knowledge and encouraging innovation.

Further Reading

Annex 4 summarizes policies for reducing emissions and increasing efficiency in 15 cities around the world.

7 Learning and Innovation

Key Messages

- **Cities have formed learning partnerships with other cities and with national governments. A next could be to take triangular international partnerships to the city level.**

- **A number of private sector programs are targeting urban innovation. Cities are seen as important business clients as well as excellent vehicles to promote sustainability.**

- **In the academic community, the system of urban research and practice needs to be optimized so that academic groups can contribute to a larger whole, and have access to the necessary funding to do so.**

- **Multilateral institutions are best placed to organize and coordinate stakeholders and their knowledge. The Urbanization Knowledge Platform, an experimental information hub convened by the World Bank, was a first step in the process.**

There is no blueprint describing how to implement sustainable development in cities, and no one-size-fits-all solution. Successful approaches are always context-specific. Thus, it is crucial for cities to be able to innovate and experiment with new institutions and policies.

Improving markets, prices or incentives may give a boost to novel technologies, but cities also need to learn approaches to sustainable development that are right for them—and that make the most of their resources. For instance, facing high risks from coastal floods, developed countries with large budgets have innovated and invested significantly in structural coastal defenses. With more limited resources, Bangladesh has had to be innovative with early warning systems, shelters, and emergency planning. Given such differing contexts, technology transfers to developing countries will sometimes not be sufficient. Cities should focus on how they can create their own responses to sustainability issues in accordance with the resources available to them.

City-specific knowledge and appropriate policies can grow from connections and exchanges between cities, national governments, the private sector, and civil society. Multilateral and academic institutions also have important roles as knowledge hubs and sources of specialized expertise.

Governments

City governments today are learning from their peers across the world. The relatively common sister-city efforts are developing into more extensive and sustained partnerships among cities of various capacities (Box 48). As discussed in Chapter 6, transnational networks of cities are increasingly important channels for learning and collective action. At the same time, dynamic partnerships between cities and their regional and national governments are becoming more frequent around the world. In many countries cities are "growing up" and gaining a more forceful voice in national and international dialogues.

Mutually beneficial South-South, South-north, and North-North partnerships and peer-to-peer learning can be augmented with additional ad hoc and permanent partners. These "triangular partnerships" are already yielding benefits at the country level (Figure 30), and moving to the city scale is likely the next phase.

*http://www.urbanknowledge.org/

BOX 48

Cities Learning from Cities

It is well-accepted that creative cities have the upper hand in promoting competitiveness, attracting business and dealing with pollution. Barcelona, Bilbao, Curitiba, and Seattle are much-discussed examples. Not only do they implement better policies, they also are role models in the way that they learn.

Seattle, for instance, is a good "learning city." City representatives have been visiting other cities since 1993 to build relationships and capture best practices. Seattle's Trade Development Alliance is committed to keeping the city at the cutting edge of urban practices, as well as establishing and maintaining relationships and promoting collective learning. This approach has been emulated by many other cities.

Dozens of cities have sought out best practices abroad. Bilbao launched its Guggenheim Museum a full 10 years after it digested lessons about industrial restructuring. Lima, long embattled over the role of private developers, saw in London the impact of private sector partnerships. There, public authorities had created clear-cut arrangements that guaranteed land and property rights in exchange for private investment in both private and public goods. That lesson helped Lima to deliberate over large infrastructure projects in metropolitan development.

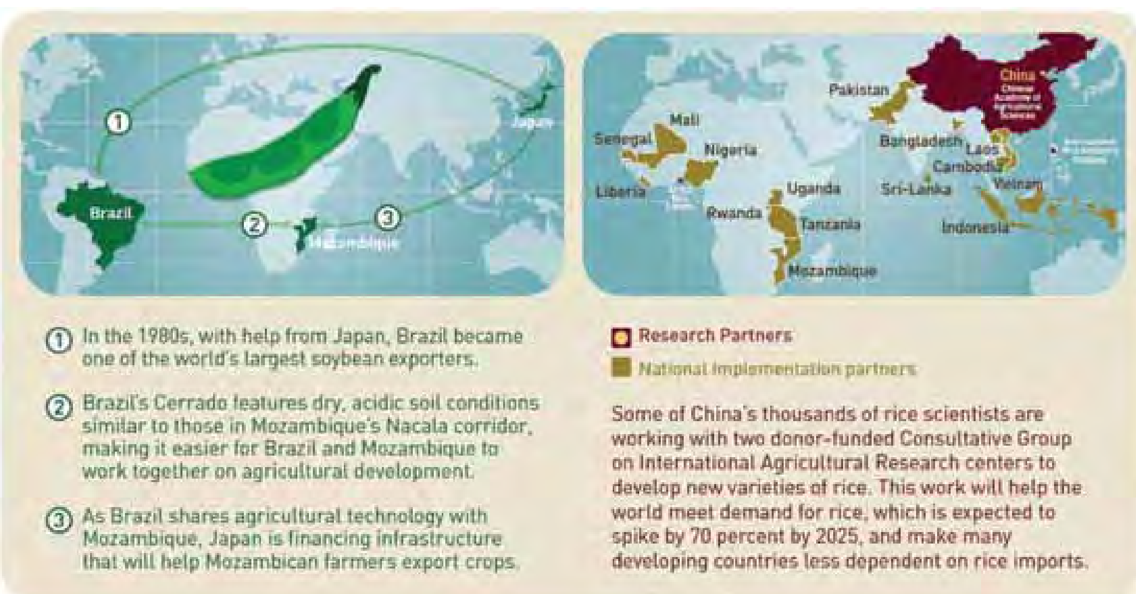


FIG. 30
Triangular Partnerships Leverage G20 Members' Comparative Advantages

Source: Reprinted from Gates (2011).

BOX 49

Businesses Benefit from Sharing Information

Campbell (2012) notes the importance of sharing and displaying private sector information related to sustainability goals. More than 4,000 companies around the world, including 400 of the world's largest 500 companies, disclose data on greenhouse gas emissions, climate risks, and governance to the Carbon Disclosure Project launched in 2001 (CDP 2012). Reporting on climate change issues seems to be correlated with corporate success; companies with the most complete disclosure and/or broadest action taken on climate change showed total returns about twice as large as a control group for the period between January 2005 to May 2011.

In addition to seeking knowledge, governments should set policies that support technological innovation. According to the OECD (2011b), the most appropriate type of policy instrument varies depending on the level of technology. In the case of promising but immature technologies, government can support research and demonstration projects and determine which infrastructure and regulatory changes are needed to promote deployment. For example, "micro-grids"—small-scale smart grid systems—are now being integrated in new ways at the neighborhood level. Several pilot programs, many with active involvement of local governments, have been established to help inform technology standards and determine whether regulatory reforms are needed.

For proven technologies that are ready to be deployed, governments may provide technology-specific support mechanisms to help jump-start the market. For alternative energy technologies that have become locally cost-competitive but still lack market share, government can promote public acceptance. For example, San Francisco's online Solar Map has been instrumental in documenting the efficacy of rooftop solar technology around the city (OECD 2011b).

Communities and Informal Networks

Informal networks or "clouds of trust" seem to help cities learn at a deeper level. These are trusted links among key actors in the community who have a stake in its future. Elected leaders come and go, but business, civic, and youth leaders who are involved in ongoing thinking about the city represent an important form of social capital. They not only bridge gaps in connectedness and reinforce social norms (Burt, R. 2001), but also provide a platform for learning and sustain the threads of continuity in a place over time.

Private Sector

Partners in the local and international business community can often contribute essential knowledge, and also benefit from learning processes in sustainable cities. Businesses that share information related to sustainability have been found to have higher returns (Box 49), and optimizing the flow of information and learning within a city can create a fertile environment for private investment and economic growth (Box 50).

Businesses should be part of any city's strategic discussion, offering the best that they can contribute—including financial and technical expertise—and the city should encourage the link between local authorities, stakeholders, and firms. The Urban Infrastructure Initiative (UII) was

BOX 50

Knowledge City, Creative City, or Informational City?

Several overlapping labels are used to describe cities that communicate and use knowledge in a sophisticated way. There are smart cities, intelligent cities, wired cities, creative cities, knowledge cities, informational cities, and many more (see, for example, Hollands 2008).

- The *knowledge city* (or knowledge-based city) has generally been defined by a narrow focus on the relationship between academic institutions and businesses in cities.
- The *creative city* enlarges the concept to include a wider set of creative professions, including the artists, architects, other designers, and, more broadly, cultural industries.
- The *smart city* label is associated with use of networked infrastructure and ICT, among other attributes (see Chapter 3).
- Manuel Cassels (1989) uses the concept of the *informational city*, which combines elements of the knowledge city and the creative city. The informational city has three key elements (Stock 2011): ICT infrastructure for communicating information (including connectivity); cognitive infrastructure for transforming information into knowledge (including humans and facilities); and infrastructure other than ICT that provides first-class leisure and retail opportunities.

Informational cities that are successful in developing ICT infrastructure, cognitive infrastructure and other amenities essentially become global cities (Sassen 2010). These are the cities that create or attract the businesses of the knowledge economy: the capital-intensive service providers, including banks, stock exchanges and insurance companies; the knowledge-intensive high-tech industries; the industrial companies of the new economy, such as computer manufacturers, software developers, and telecommunications and Internet firms, as well as information service providers; and creative companies ranging from architectural firms to advertising agencies.

Achieving such economic success does not, however, make a city sustainable. Cities participating in the knowledge economy will grow or maintain their wealth, as they will participate in the ownership of new assets (Kennedy 2011). But the mix of new knowledge and creativity does not necessarily lead to green products or to environmentally sustainable cities. This depends primarily on having suitable data (such as the urban indicators discussed in Chapter 5) and the political will and leadership to make green growth a primary policy goal.

launched in 2010 by the WBCSD to demonstrate how business can unlock opportunities and develop practical solutions toward sustainable cities (Box 51). For example, the UII harnesses WBCSD's project work in areas such as water, electric utilities, and energy efficiency in buildings, along with many years of business expertise and experience working with cities. It also brings in the best available experts from 14 global companies. The UII team then partners with selected cities around the world to explore and identify solutions for sustainable urbanization and urban infrastructure.

The IBM-originated Urban Systems Collaborative (see Box 53) represents a growing trend for major corporations to explore the future of cities. Among the companies participating in the Sustainable Cities Partnership, four of the most visible initiatives are Smarter Cities from IBM, Connected Urban Development from Cisco, Green City Indices from Siemens, and the Livable Cities program from Philips.[29]

Private sector involvement is motivated by branding, sales, and philanthropy, and reflects the importance that the corporate world gives to cities. For example,

[29]Representatives from all four companies, plus Alstom, Veolia, GDF Suez, and PricewaterhouseCoopers, attended the June 2011 workshop of the Sustainable Cities Partnership.

BOX 51

The Urban Infrastructure Initiative

The UII is an integrated approach with the ability to mobilize a wide range of expertise and competencies from participating companies. UII member companies include Acciona, Aecom, AGC, CEMEX, EDF, GDF Suez, Honda, Nissan, Philips, Schneider Electric, Siemens, TNT, Toyota, and UTC. The group's co-chairs are CEMEX, GDF Suez, Siemens, and the WBCSD. Participating companies are sustainability pioneers who are aware of the interconnected nature of sustainable cities. An external Assurance Group comprised of six prominent experts in areas such as housing and development, urban design, and architecture reviews UII work, provides quality approval and feedback, and helps the team in its reflections on how to proceed. Together, the team handles most urban issues from waste to security, energy, water and sewage, buildings and housing, mobility, logistics, and health. They can also offer an end-to-end solution covering the entire life cycle of a city's infrastructure.

Each UII project uses a systemic approach to green urbanization and urban infrastructure, while providing strong leadership and guidance. UII projects begin with the identification of cities that are planning sustainability projects with possible sponsors or financers, dialogue with city officials to understand their vision and main challenges, determining and prioritizing solutions to address the main issues, identifying tangible projects and measures, and involving the appropriate experts from the UII.

To date, the UII core team has worked with Philadelphia; Surabaya, Indonesia; Tilburg, the Netherlands; Turku, Finland; and four cities in the Indian state of Gujarat. UII will also work with cities in China and Japan. The approaches vary across cities. Outputs include advances in biogas production, building automation (cutting energy used by systems such as heating, ventilation, and air conditioning through electronic communication among equipment), energy performance in public lighting and public buildings, green logistics, and reducing congestion.

The UII's key lessons thus far are that (a) there is great value in involving business in the early stages of a city's sustainability planning, (b) cities must also create the right framework conditions and incentives to attract the necessary investments, and (c) multi-stakeholder expertise is essential to help transform cities' sustainability visions into effective and affordable plans.

IBM's Smarter Cities program[30] is part of a strategy to associate the company with capacity to generate system-level solutions to complex problems. Once the program was started, IBM's business and research divisions got involved, compiling the company's many city-based consulting contracts into a package of practice that could be studied, generalized, and replicated.

Cisco Systems has an internal think tank, the Internet Business Solutions Group (IBSG),[31] charged with identifying long-term commercial opportunities for their core business of networking hardware and software. One of IBSG's programs, Connected Urban Development (CUD),[32] began in 2006 through collaboration with the cities of Amsterdam, San Francisco, and Seoul, as well as other government and corporate partners. CUD created Web sites called Urban EcoMaps[33] that could educate city dwellers about ways to reduce their environmental impacts.

As the CUD program expanded with the involvement of other cities, it gave rise to broader initiatives, including Smart and Connected Communities, and Planetary Skin. In 2010, Cisco handed the leadership of CUD to Metropolis and the Climate Group. Like IBM, Cisco has convened a series of international conferences to share the potential of these programs with leaders from development banks, scholars, and city- and environment-focused NGOs.

While IBM and Cisco focus on information flows within urban systems, Siemens' core business is targeted to the creation and maintenance of urban infrastructure. In 2011, responding to the growing interest in a green built environment, Siemens created a special division—Infrastructure and Cities—pulling together many of its city-related offices. Siemens is well positioned to help create solutions for urban issues such as greenhouse gas reduction, cleaner transportation systems, and health care delivery in cities of the developing world. Its Green City Indices (Annex 2) are among the urban data-gathering programs reviewed in Chapter 5.

Philips has also chosen a focused approach in line with its particular strengths. Its Livable Cities program[34] is centered on how lighting can influence the quality of city life, improve public safety, increase energy efficiency, and enhance mental health. Similarly, PricewaterhouseCoopers uses its accounting expertise to lead a program that calculates the GDP of cities.[35]

Other notable corporate partners include Alstom and Veolia Environment. Alstom[36] focuses on urban energy and transport infrastructure and how ICT can help to optimize efficiency and reduce carbon dioxide emissions (smart city technology is discussed in Chapter 3). The company has taken the lead in the first international development program for carbon-neutral eco-cities and runs dozens of pilot programs to test new technologies for smart cities, in partnership with local utilities. In 2010, Alstom formed a venture company named EMBIX with France's Bouygues group to provide energy management services for eco-cities.

Veolia Environment[37] focuses on urban systems management. Their four divisions (water, energy, waste, and transportation) cover all the service needs of cities. Since the beginning of the decade, Veolia has pushed a systems approach to urban sustainability and supported a number of research centers and collaborations dealing with such topics as city operations, human behavior, and attitudes.

In sum, large corporations are aware that cities are important clients for their services as well

[30]http://smartercities.tumblr.com/
[31]http://www.cisco.com/web/about/ac79/index.html
[32]http://www.connectedurbandevelopment.org
[33]http://urbanecomap.org/

[34]http://www.meaningfulinnovation.philips.com/Livable-Cities/
[35]http://www.ukmediacentre.pwc.com/Media-Library/Global-city-GDP-rankings-2008-2025-61a.aspx
[36]http://www.alstom.com
[37]http://www.veolia.com/en/

as excellent vehicles to promote sustainability. Some of the initiatives may overlap, and there is competition among consulting firms to advise city management. Although competition is healthy in principle, the development of parallel frameworks and indicators may result in dispersion of efforts and difficulty in comparing performance. Over time, however, there will likely be specialization, with different firms offering unique products in support of sustainable cities.

Academia

Much urban innovation to date has come from city officials, practicing planners and architects, nonprofit foundations, and corporations that serve city governments and citizens. Conspicuously absent from this list are university scientists and engineers. This minimal role can be attributed in part to the reward system of academia, which encourages research in areas that receive major federal funding. Because cities tend to fall through the disciplinary cracks, faculty interested in addressing urban sustainability problems have not had many opportunities to obtain the largest and most prestigious grants from agencies like the European Science Foundation or the U.S. National Science Foundation, or from the most prominent private foundations.

Nonetheless, the growing emphasis on sustainability in colleges and universities has provided a context in which urban problems can be more widely addressed. An increasing number of universities have cross-cutting sustainability initiatives that can help quantify the economic, environmental, and social impacts of cities. In particular, ways to measure urban metabolism (see Chapter 5) and carbon footprints were developed in universities and then moved into practice among cities. Some academic institutions have been able to apply more specialized expertise—from space flight to climate modeling—to help cities address sustainability issues (Box 52).

BOX 52

Channeling Specialized Expertise in Academia

There are many examples of how universities exploit unusual expertise to advance their urban agendas. MIT's SENSEable City Lab[a] and the Centre for Advanced Spatial Analysis at University College London[b] have been pioneers in the use of cell-phone positional information and social media traffic to make complex urban dynamics more tangible. These groups are emerging as the preferred academic partners for many cities and companies seeking to exploit these new technological approaches.

Arizona State University's Mars Space Flight Facility[c] has been designing and controlling instruments that map Mars and other planetary bodies for more than 25 years. Over the past decade, they have turned their unique expertise in remote sensing and global-scale data management toward the monitoring and modeling of cities. With NASA funding, corporate aerospace partnerships, and a collaborative history with Google, they are developing an urban information system called J-Earth, which will allow virtually any type of urban data to be combined, co-registered, searched, and analyzed.

Finally, in London, the multi-university Tyndall Centre for Climate Impact Research has worked unusually closely with city officials to analyze how climate change may affect different aspects of the city's habitability, ranging from flooding to the urban heat-island effect to traffic congestion.[d] The Tyndall London methodology is now being considered for adoption by other cities.

a. http://senseable.mit.edu
b. http://www.casa.ucl.ac.uk/
c. http://mars.asu.edu/
d. http://www.ceg.ncl.ac.uk/info/pdf/engineeringcites.pdf

Urban universities that see the improvement of their local environments as part of their training, research, and service missions are best positioned to partner with government agencies and officials. Such collaborations are becoming increasingly common, especially as municipal budgets continue to be cut. One good example is the Future Cities Centre[38] being developed in London by a group of universities and private sector entities, including University College London, Cisco, and Arup.

Chicago and Portland offer similar examples. The University of Illinois–Chicago established the Great Cities Institute (GCI)[39] in 1993 as a focal point for studies of Chicago that also have relevance to other major cities around the world. In its nearly 20 years of existence, the GCI has partnered with several hundred local, regional, national, and global private and public sector organizations. In conjunction with strong mayoral and corporate leadership, the GCI has helped place Chicago at the forefront of cities coordinating innovative policy thinking and action. Portland State University[40,41] has worked with the City of Portland, the Metro Regional Government, and local and state agencies to bring the green urban innovations for which their region is well known to other cities across the United States, with the assistance of other members of the Coalition of Urban-Serving Universities.[42]

As with competing corporations, universities tend to have difficulty sharing the limelight with each other, especially when reputation and funding are at stake. Schools that establish partnerships with individual cities, foundations, or companies prefer not to give up or share those exclusive pipelines, and competition for large grants is always fierce. Hence, optimizing the system of urban research and practice so that each academic group can contribute to a larger whole, rather than trying to replicate what others are doing, requires an unusual level of cooperation.

Two circumstances could foster a system of academic collaboration. If a globally oriented network initiative were to become firmly established and funded—for example, ICLEI's STAR index—each urban-oriented university could team up with its local municipal partner to assure that their city has a prominent role in the collective enterprise. Second, if a university has a widely acknowledged and uniquely valued asset, others might be more willing to include them in any potential consortia.

In more traditional scientific disciplines, the establishment of major centers, institutes, or facilities through concentrated government funding has provided the kind of focus that has in turn allowed a more collaborative community to emerge. No such academically based initiative has yet been created in the United States. Large-scale (over $2 million per year) funding of an urban-focused Science and Technology Center or Engineering Research Center by the U.S. National Science Foundation could have such a catalyzing effect.

The Development Community

A fundamental difficulty associated with coordinating the different types of urban information and programs outlined above is the lack of an obvious organization that has the necessary authority and resources to forge consensus. The budgets of virtually all the world's city governments are being tightly squeezed. Academic researchers, at least in the United States, have been unsuccessful in convincing funding agencies that cities are worth major investments. Although many cash-rich corporations express interest in promoting the understanding of cities, they have generally been unwilling to commit their funds to urban research

[38]http://www.imperial-consultants.co.uk/news/2011/imperial-college-london-ucl-and-cisco-create-future-cities-centre-london
[39]http://www.uic.edu/cuppa/gci/
[40]http://www.pdx.edu/usp/
[41]http://www.pdxinstitute.org
[42]http://www.usucoalition.org

programs that mostly benefit the public rather than their companies' share value. Some smaller philanthropic foundations have begun to support urban research programs, but only at modest funding levels.

Arguably the only relevant players that have a global reach and maintain access to sizeable pools of capital are multilateral development banks (MDBs) such as the World Bank, Inter-American Development Bank, and Asian Development Bank, and branches of the United Nations such as UN-Habitat and UNESCO. These organizations have a history of working collaboratively to promote regional socioeconomic objectives, including infrastructure development and institution-building.

Some examples of successful collaboration efforts among partners which have yielded useful tools and platforms for city learning include the Global Protocol for City and Community GHG Accounting (GPC) and the Knowledge Centre on Cities and Climate Change. The GPC was developed by ICLEI, C40, WRI, the World Bank, UN-Habitat and UNEP to serve as the global framework for accounting and reporting city and community-scale GHG emissions[43]. The GPC is expected to help cities and communities measure their GHG emissions to ensure that all emissions are being accounted for between different government municipalities. The Knowledge Centre on Cities and Climate Change (K4C) is the product of a Joint Work Programme between UNEP, Cities Alliance, UN-Habitat and the World Bank[44]. The K4C is a platform for sharing experiences and best practices, as well as facilitating exchange of innovative initiatives. It provides access to hundreds of publications and reports which are mapped to specific cities, countries and regions.

43 http://www.ghgprotocol.org/city-accounting
44 http://www.citiesandclimatechange.org/

The difficulty in getting the support of MDBs or the UN for urban initiatives is that they have tended to focus on countries or regions rather than cities or metropolitan areas. Yet in the past few years the banks have been showing a growing recognition of the need for more urban-scale actions. They also have the credibility and convening authority that most members of other sectors lack. A consortium of development banks could bring together representatives from federal, state, and municipal governments, corporations, NGOs, philanthropies, and universities to design a grand scheme for urban information management and policy creation in support of global sustainability objectives. Workshops on urban issues have already spawned a multitude of knowledge networks and follow-up initiatives, but these have gained little traction in the absence of central coordination (Box 53).

Further Reading

Annex 2 describes Siemens' Green City Index series in detail.

Annex 13 is a detailed discussion of how the cities' use of "e-government" services relates to both their ICT capabilities and their growing power as global players.

Annex 14 reviews pilot programs for innovative technology, services, and business models, and discusses general issues and lessons for such pilots.

Annex 15 discusses how city planning could evolve with the growth of ICT, and the infrastructure and capacities required for this.

Annex 16 describes the World Bank's Eco2 Cities Initiative, which helps cities design development pathways for both ecological and economic sustainability.

BOX 53

Organizing Information from Urban Conferences

Interest in tools and data flows for urban sustainability continues to expand rapidly among government, academic, corporate, and NGO players. In fact, the proliferation of well-intentioned urban solutions, workshops, and strategic plans from all these sectors is becoming an unanticipated threat to achieving sustainability goals—nobody can keep track of all of them, let alone determine how they might be best integrated.

New meetings commonly propose new knowledge hubs. For example, the Urban Systems Collaborative (USC) is an ad hoc initiative that grew out of an IBM-sponsored symposium on "Smarter Cities" held in New York City in May 2011. The USC started as a series of bi-weekly conference calls with 20–40 participants, and then evolved to include specific projects such as a student competition, a Web-based reference repository, and a series of webinars. Contributors were encouraged to invite others to join, interact on a dedicated wiki, and propose new components. There was no identified funding source, and labor to set up the constituent programs was voluntary.

Hundreds of other large and small urban-themed conferences in recent years have compiled presentation materials online, set up informal networks among participants, and proposed the creation of follow-on urban initiatives. The majority of these efforts become dead ends, largely unreferenced and forgotten, even by the conveners. Clearly, there is a pressing need to establish some sort of clearinghouse for conferences on cities and the products they generate. This requires identification and screening by some organization, confederation, or Web site, and willingness on the part of the community to coordinate and reduce the number of meetings they hold.

Photo: Shutterstock

PART IV
The Path Forward

Photo: Jerry Kurniawan /World Bank

8 Next Steps Toward Sustainable Cities

In just 40 years cities will need to build the infrastructure for an additional 2.7 billion people (Annex 1). As we have seen, power, water, waste, and transportation systems need to be created, as well as local economies, governance systems, and jobs. This city-building task is enormous. Never has humanity faced as large a challenge, especially since many natural ecosystems are already well beyond the sustainable carrying capacity of today's 3.5 billion urban residents. Sustainably building and managing new cities and retrofitting existing urban areas are imperative. There are a only a few decades to ensure that the next wave of urbanization does not lock in the limitations of most of today's cities.

Cities are where everything comes together: our ideas, our culture, our economies, our aspirations, and so too our impacts on the planet, our vulnerabilities, and, increasingly, much of our inequality. Green and inclusive growth can proceed only if it is well and truly anchored at the city level. The Sustainable Cities Partnership is just one example of how the issue of cities can bring together a disparate collection of stakeholders, all of whom have much to gain by participating, and much to contribute to sustainable cities.

Next Steps for Cities and Their Partners

The Urbanization Knowledge Platform held extensive consultations with city leaders, development practitioners, policymakers, and academics in 13 countries and 5 regions. The goal was to discuss stakeholders' issues and concerns about enhancing citizen welfare, the economic contributions of urbanization, and sustainable urban development. Based on these consultations, seven critical urban challenges emerged. Table 8 summarizes these challenges and the associated needs.

TABLE 8
Key Challenges for Sustainable Urban Development

Challenge	Needs
Tailoring research and best practices to the particular context and needs of different types of cities	City-level data to develop a typology of cities
Harnessing opportunities to transition to knowledge economies	Enabling environment for knowledge creation and entrepreneurship
Upgrading well-being for citizens, businesses, investors, and visitors	Plans to fill fundamental infrastructure and service deficits, with the corresponding financing and delivery mechanisms
Developing sustainable, smart cities	Mainstreaming of sustainability issues in the planning, design, and construction communities, and innovation at all stages of development
Fostering civic renewal, citizen trust, and public confidence in city leadership	Two-way communication with government, institutional strengthening, and collaboration with civil society
Redefining the city's relationship with (supra-)national bodies in view of the absence of binding international agreements on climate change, sustainability, and green growth	Establishment of a new format based on partnerships among cities, the private sector, academia, and civil society
Enabling city learning and peer-to-peer sharing for city leaders	Open data, standardized city indicators, benchmarking of cities, and municipal networks to facilitate the exchange of knowledge

To develop sustainably, cities need a credible voice in global policies, finance to speed implementation, and access to information. The Sustainable Cities Partnership has identified specific areas for cities and their partners to focus on:

- *Data collection:* Cities and their agencies should collect relevant and credible information and apply practical tools to help improve decision making for cities. The data needs to provide a composite picture of their environmental impacts and overall consumption, emissions, and outputs—that is, their urban metabolism. This will allow diagnostics, benchmarking, and relevant indicators to be established for cities, which in turn enable cities to track their service delivery and well-being over time and compared to other cities. Such comparison are particularly useful for cities to learn from one another and form networks around common objectives.

- *Assessing paths to sustainability at sector level:* Cities and their agencies should gather data with a special focus on buildings (retrofitting, reuse, new green building codes), energy efficiency (sources of loss, potential efficiency gains), transport (fleet composition, capture of land value increases, role of personal vehicles, type of fuel, electrification policies), land use planning and density management, and basic service provision (water, wastewater, solid waste, drainage).

- *Costing the alternatives and acquiring stable finance:* Cities should encourage the use of frameworks such as natural capital accounting, and ensure that these are applicable at the local level.

- *Discussing and articulating local sustainability goals:* Cities should mainstream sustainability planning into multi-year development planning processes. They should articulate their own sustainable development goals and encourage their national governments to aggregate these. Useful models for urban sustainability planning include Local Agenda 21, the Urban Environmental Accords, City Development Strategies, Green Plans, and Sustainability Master Plans. The planning process should involve considering sustainability within traditional cost-benefit analysis, garnering public support, and identifying sources of finance that can make these long-term plans affordable for the city budget.

- *Sharing knowledge among institutions:* Cities, institutions, and partners should work toward the use of common tools to guide, monitor, and communicate progress. These include the Global Protocol for Community-Scale GHG Emissions.[45] the GCIF, and UNEP's Knowledge Centre on Cities and Climate Change.[46] The use of information nodes by institutions at the city, regional, national, and international levels will ensure that credible information on sustainable cities is widely available and regularly updated.

- *Collaborating with partner cities in other parts of the world:* Cities should partner to share important lessons, facilitate innovation, and help to spread a new sustainable cites paradigm.

Next Steps for the Sustainable Cities Partnership

The Sustainable Cities Partnership is an evolving network rather than a formal body with a uniform agenda. The group as a whole has agreed on broad aspirations, while individual members are pursuing specific programs that are aligned with their own core objectives as well as the mission of the wider partnership.

[45] http://www.ghgprotocol.org/city-accounting
[46] http://www.citiesandclimatechange.org/

Going forward, our general goals are to:

- Develop a common lexicon of terms, tools, and metrics for sustainable cities.

- In the public sector, identify the benefits derived from well-functioning public institutions; discuss policy alternatives, including carbon tax and fuel subsidies; and have open dialogue with constituents regarding the legitimate issues faced by cities and the urgency of moving forward.

- Highlight the role of the private sector and mobilize businesses to help innovate investment products, processes, and institutions for sustainable urban development, while ensuring that the needs of cities and their residents are met.

- Develop a decision-making framework based on a simple, qualitative, multi-dimensional analysis that captures the various impacts of green growth policies.

More specifically, the partnership can contribute to a variety of urban sustainability objectives (Table 9), and several concrete commitments have been made. Partners plan to collectively develop some key building blocks of sustainable cities, working along the following lines of action:

- The World Bank and other partners will periodically compile and disseminate the Large Urban Areas Compendium introduced in Chapter 5. Partners also plan to provide available city data to the GCIF for standardized data monitoring, and to regularly update information relevant for cities at different levels of development, emissions, and technological capacity.

- Partners will provide coordinated input to other key products, such as standardized risk evaluations using the Urban Risk Assessment methodology (Box 38).

- The Institute for Sustainable Infrastructure (ISI) is taking the lead to develop an infrastructure rating tool. As part of a memorandum of understanding on climate change and common urban metrics signed by all IFIs at meetings of the IPCC in December 2010 and 2011, the infrastructure rating tool will provide a platform to assess the sustainability of infrastructure projects. Those projects with a particularly high sustainability rating may be eligible for preferential funding, such as green bonds. As of June 2013, a draft of the tool exists and is being piloted by several engineering firms.

- Annex 19 presents the South Africa Cities Accord that emerged during the Durban COP17. The Accord recognizes that urban data collection should first rest with respective cities. Annual and open publication is best. Where practical, city indicators should have a globally recognized format or standard.

- The USGBC, in partnership with the World Green Buildings Council, is leading the development of a common guideline for green buildings. As shared guidelines emerge, cities are expected to support their widespread application, as are agencies such as the World Bank and members of the Sustainable Cities Partnership.

- City agencies like C40 and ICLEI—as well as national city associations, national governments, and international organizations—are working with cities to develop new strategies for coordinating sustainable development, meshing urban climate change mitigation, adaptation, and basic service delivery. An example is the Climate and Clean Air Coalition (CCAC), a broad and growing partnership that aims to reduce short-lived climate pollutants such as methane, black carbon, tropospheric ozone, and hydrofluorocarbons. CCAC includes an initiative on solid waste management.

TABLE 9 Moving Forward in the Sustainable Cities Partnership

City Objective	Tools	Existing Sources	Role of the Partnership
Understanding the city, its ecological impacts and the structure of its emissions	Indicators and data collection ▸ greenhouse gas inventory ▸ sustainability ▸ ecosystem services Rapid sustainability assessment	GCIF ICLEI and C40 UNEP City planning	Promotion and support Use of common tools
Comparison with relevant cities	Benchmarks according to income, density, production, and geographic groups	Green indexes Common and regular metrics	Developing a more operational definition of "sustainable city" Training
Assessing alternative paths to sustainability	Energy efficiency Building codes Building retrofitting Transport policies Land development Water, wastewater, and solid waste	ESMAP UNEP Local and national master plans Remote sensing	Developing toolkits Associating city typology with interventions
Costing alternatives	Broader cost-benefit analyses	Private sector, MDBs, cities	Promoting internalization of more externalities
Including sustainability goals in capital improvement plans	Infrastructure sustainability ratings Local citizen support	Local-national agreements	ASCE, WFEO and ISO infrastructure rating tool
Financing	Climate finance, political autonomy	Local and national revenues	MDB partnership private sector
Implementation and follow-up	Reports, seminars, internet information warehousing	UrbKP	Expand and link UrbKP

- The WBCSD will work with the Sustainable Cities Partnership to develop an approach for cities to create smart city platforms. This should be broad enough for cities in both developing and developed countries, and structured to facilitate clear and publicly communicated public-private partnerships.

As urbanization continues apace and efforts toward sustainable development intensify, cities will need greater cooperation and more partnerships. These partnerships are often likely to be ad hoc and transient, but in other cases trust will grow, ties will strengthen, and cities and their agents should benefit significantly. This report is intended to nurture a stronger relationship between the varied players in the urban space. The needs are enormous and urgent, but so too are the opportunities.

References

Alberti, M., J. Marzluff, E. Shulenberger, G. Bradley, C. Ryan, and C. Zumbrunnen. 2003. "Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems." *Bioscience* 53(12): 1169-79.

AINCA. 2008. *Consejo Territorial de Planeación de Soacha. Política Pública: Desarrollo Económico Incluyente del Municipio de Soacha*. Departament of Cundinamarca, Colombia.

AMWA (Association of Metropolitan Water Agencies). 2007. *Implications of Climate Change for Urban Water Utilities.* Washington, DC: AMWA.

Arup, The Climate Group, Accenture and Horizon, and University of Nottingham. 2011. *Information Marketplaces: The New Economics of Cities.*

ASEAN Studies Center. 2010. *Urbanisation in Southeast Asian Countries.* Institute for Southeast Asian Studies.

Avent, Ryan. 2011. *The Gated City*. Amazon Digital Services.

Baccini, P. B. 1991. *Metabolism of the Anthroposphere*. Berlin: Springer Verlag.

Baeumler, A., E. Ijjasz-Vasquez and S. Mehndiratta. 2012. *Sustainable Low-Carbon City Development in China*. World Bank, Washington DC.

Bai, Xueimei, and Hidefumi Imura. 2000. "A Comparative Study of Urban Environment in East Asia: Stage Model of Urban Environmental Evolution." *International Review for Environmental Strategies*,1 (1), 135–158.

Baker-Gallegos, Julianne. 2010. *Disaster Risk Reduction in a Peri-Urban Informal Settlement: the importance of links across scales.* Paper presented at the Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS II), Ann Arbor, MI.

Barnett, J. 2001. "Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty". *World Development* 29, 977–993.

Beatley, Timothy. 2007. "Envisioning Solar Cities: Urban Futures Powered by Sustainable Energy." *Journal of Urban Technology* 14 (2).

Berkes, F., and C. Folke, editors. 1998. *Linking sociological and ecological systems: management practices and social mechanisms for building resilience.* Cambridge University Press, New York, New York, USA.

Bicknell, Jane, David Dodman, and David Satterthwaite. 2009. *Adapting Cities to Climate Change, Understanding and Addressing the Development Challenge.* New York: Earthscan.

Bigio, Anthony. 2011. *Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa*. Washington, DC: World Bank.

Bizikova L., T. Neale and I. Burton 2008. *Canadian communities' guidebook for adaptation to climate change. Including an approach to generate mitigation co-benefits in the context of sustainable development.* First Edition. Environment Canada and University of British Columbia.

Bogner, J., A. M. Abdelrafie, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, and T. Zhang. 2007. "Waste Management." In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. B. Metz, O. R. Davidson, P. R. Bosch, R., and L. A. Meyer. Cambridge and New York: Cambridge University Press.

Bollen, B. Guay, S. Jamet, and J. Corfee-Morlot. 2009. *Co-benefits of Climate change Mitigation Policies: Literature Review and New Results.* Economics Department Working Papers No. 693 Paris: OECD.

Brown, Lester. 1978. *The Twenty-Ninth Day*. W. W. Norton.

Brown, M. A. 2009. "The Geography of Metropolitan Carbon Footprints." *Policy and Society* 27 (4), 285–304.

Bulkeley, Harriet, Heike Schroeder, Katy Janda, Jimin Zhao, Andrea Armstrong, Shu Yi Chu, and Shibani Ghosh. 2011. In *Cities and Climate Change: Responding to an Urgent Agenda*, eds. Daniel Hoornweg, Mila Freire, Marcus J. Lee, Perinaz Bhada-Tata, and Belinda Yuen, Ch. 5. Washington, DC: World Bank.

Burdett, R. S. 2011. *Living in the Endless City: The Urban Age Project by the London School of Economics and Deutsche Bank's Alfred Herrhausen Society*. London: Phaidon Press.

Campbell, T. 2012. *Beyond Smart Cities: How cities network, learn, and innovate*. New York, NY: Earthscan.

C40 (Cities Climate Leadership Group). 2010a. *Best Practices Copenhagen*. C40.

C40. 2010b. *San Francisco Solar Power System (2004–2010).* C40.

C40 and Arup. 2011. *Climate Action in Megacities: C40 Cities Baseline and Opportunities*. C40.

Carslaw, David C., and Sean D. Beevers. 2005. "Estimations of Road Vehicle Primary NO Exhaust Emission Fractions using Monitoring Data in London." *Atmospheric Environment* 39 (2005), 167–177.

Castells, Manuel. 1989. *The Informational City: Information Technology, Economic Restructuring, and the Urban-Regional Process*. Oxford, UK: Basil Blackwell.

CDP (Carbon Disclosure Project). 2011. *CDP Cities 2011: Global Report on C40 Cities*. CDP.

CDP. 2012. *Measurement for Management: CDP Cities 2012 Global Report*. CDP.

Chapin, F. S., III, P. A. Matson, and H. A. Mooney. 2002. Principles of terrestrial ecosystem ecology. Springer, New York.

Chelani, Asha B., and Sukumar Devotta. 2007. "Air Quality Assessment in Delhi: Before and After CNG as Fuel." *Environmental Monitoring and Assessment* 125 (1–3), 257–263.

Chen, S. and M. Ravallion. 2008. *The developing world is poorer than we thought, but no less successful in the fight against poverty*. Washington, DC: Development Research Group, World Bank.

Cheshire, Paul, and Stefano Magrini. 2009. "Urban Growth Drivers in a Europe of Sticky People and Implicit Boundaries." *Journal of Economic Geography* 9 (1), 85–115.

Chrysoulakis, N. 2008. "Urban Metabolism and Resource Optimization in the Urban Fabric: The BRIDGE Methodology." In *Proceedings of EnviroInfo 2008: Environmental Informatics and Industrial Ecology*, September 10–12, Leuphana University of Lüneburg, Germany, Vol. 1, 301–309.

Ciccone, A. 2002. "Agglomeration Effects in Europe." *European Economic Review* 46 (2002), 213–227.

Ciccone, A., and R. E. Hall. 1996. "Productivity and the Density of Economic Activity." *The American Economic Review* 86 (1), 54–70.

Clean Air Task Force. 2005. *An Analysis of Diesel Air Pollution and Public Health in America*. Boston: Clean Air Task Force.

Climate Group. 2009. *Smart 2020: Enabling the Low Carbon Economy in the Information Age*. Climate Group.

Congress for the New Urbanism. 2001. "Charter of the New Urbanism." Congress for the New Urbanism. http://www.cnu.org/charter

Cromwell, John, Joel B. Smith, and Robert S. Raucher. 2007. *Implications of Climate Change for Urban Water Utilities*. Washington, DC: Association of Metropolitan Water Agencies.

Derissen, S., M. Quaas, and S. Baumgartner. 2009. "The relationship between resilience and sustainable development of ecological-economic systems." *Ecological Economics* 70: 1121-1128.

Dhakal, S. 2009. "Urban energy use and carbon emissions from cities in China and policy implications." *Energy Policy* 37 (11), 4208–4219.

Dobbs, Richard, Sven Smit, Jaana Remes, James Manyika, Charles Roxburgh, and Alejandra Restrepo. 2011. *Urban World: Mapping the Economic Power of Cities*. McKinsey Global Institute.

Dora, C. 2007. "Health Burden of Urban Transport: The Technical Challenge." *Sadhana* 32 (4), 285-292.

EIB (European Investment Bank). 2010. Public and Private Financing of Infrastructure: Policy Challenges in Mobilizing Finance. Luxembourg: EIB.

Estache, Antonio. 2010. *A Survey of Impact Evaluations of Infrastructure Projects, Programs and Policies*. ECARES Working Paper 2010-005. ECARES (European Centre for Advanced Research in Economics and Statistics).

European Commission, 2008. *Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings*. Brussels.

Felson, Marcus, and Joe L. Spaeth 1978. "Community Structure and Collaborative Consumption: A Routine Activity Approach." *American Behavioral Scientist* 21 (4), 614–624.

Fischer-Kowalski, Marina. 1998. "Society's Metabolism." *Journal of Industrial Ecology* 2 (1), 61–78.

Fitzhugh, T. W. and Richter, B. D. 2004. "Quenching Urban Thirst: Growing Cities and Their Impacts on Freshwater Ecosystems." *Bioscience* 54 (8): 741–754

Folke C., S.R. Carpenter, T. Elmqvist. 2002. "Resilience and sustainable development: building adaptive capacity in a world of transformations." *Ambio* 31 (5): 437-440.

Fuchs, E. R. 2012. "Governing the Twenty-First-Century City." *Journal of International Affairs* 65 (2), 43–56.

Gates, Bill. 2011. *Innovation With Impact: Financing 21st Century Development*. Bill & Melinda Gates Foundation.

Geller, H., P. Harrington, A.H. Rosenfeld, S. Tanishima, F. Unander. 2006. "Polices for increasing energy efficiency: Thirty years of experience in OECD countries." Energy Policy 34(5): 556-573.

Geothermal Energy Association. 2010. *Geothermal Energy: International Market Update*.

GIZ (German Agency for International Cooperation). 2009. *Urban Transport and Climate Change Action Plans: An Overview*. GIZ.

Giusti, L. 2009. "A review of waste management practices and their impact on human health." *Waste Management* 29(8): 2227-2239.

Glaeser, Edward. 2011. *The Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*. Penguin.

Goodland, Robert, and Herman Daly. 1996. "Environmental Sustainability: Universal and Non-negotiable." *Ecological Applications* 6 (4), 1002–1017.

Gusdorf, F., and S. Hallegatte. 2007. "Compact or Spread-Out Cities: Urban Planning, Taxation, and the Vulnerability to Transportation Shocks." *Energy Policy* 35 (2007), 4826–4838.

Gusdorf, F., S. Hallegatte, and A. Lahellec. 2008. "Time and Space Matter: How Urban Transitions Create Inequality." *Global Environment Change* 18 (4), 708–719.

Hallegatte, Stéphane. 2008. "Strategies to adapt to an uncertain climate change," *Global Environment Change* 19 (2), 240–247.

Hallegatte, Stéphane, Geoffrey Heal, Marianne Fay, and David Treguer. 2011. From Growth to Green Growth: A Framework. *Policy Research Working Paper* 5872. Washington, DC: World Bank.

Heal, Geoffrey. 2005. "Corporate Social Responsibility: An Economic and Financial Framework." *The Geneva Papers on Risk and Insurance: Issues and Practice* 30 (3), 387–409.

Hollands, Robert G. 2008. "Will the Real Smart City Please Stand Up?" City 12 (3), 303–320.

Holling, C. S. 2001. "Understanding the complexity of economic, ecological, and social systems." *Ecosystems* 4(5):390-405.

Holm, A. 2010. *Geothermal Energy: International Market Update*. Geothermal Energy Association.

Hoornweg, Daniel, and Perinaz Bhada-Tata. 2012. *What a Waste: Waste Management around the World*. Washington, DC: World Bank.

Hoornweg, Daniel, and Perinaz Bhada-Tata. In press.

Hoornweg, Daniel, Mila Freire, Marcus J. Lee, Perinaz Bhada-Tata, and Belinda Yuen, eds. 2011. *Cities and Climate Change: Responding to an Urgent Agenda*. Washington, DC: World Bank.

Hoornweg, Daniel, Fernanda Ruiz Nuñez, Mila Freire, Natalie Palugyai, Maria Villaveces, and Eduardo Wills Herrera. 2007. *City Indicators: Now to Nanjing*. Washington, DC: World Bank.

Hoornweg, Daniel, Lorraine Sugar, and Claudia Lorena Trejos Gomez. 2011. "Cities and Greenhouse Gas Emissions: Moving Forward." *Environment and Urbanisation* 23 (1), 207–227.

X. Hu, S. Chang, J. Li, and Y. Qin. 2010. "Energy for sustainable road transportation in China: Challenges, initiatives and policy implications." *Energy* 3(11): 4289–4301.

Ibisch, Pierre L., Alberto Vega E., and Thora Martina Herrmann, eds. 2010. *Interdependence of Biodiversity and Development under Global Ghange*. CBD Technical Series No. 54. Montreal: Secretariat of the Convention on Biological Diversity

ICLEI (International Council for Local Environmental Initiatives). 2011. *Financing the Resilient City: A demand driven approach to development, disaster risk reduction and climate adaptation*. Bonn: an ICLEI Global Report.

IEA (International Energy Agency). 2008. *World Energy Outlook 2008*. Paris: OECD.

IEA and OECD. 2010. *World Energy Outlook 2010*. Paris: OECD.

Jaffe, A. B., and R. N. Stavins. 1994. "The Energy Paradox and the Diffusion of Conservation Technology." *Resource and Energy Economics* 16 (2), 91–122.

JICA (Japan International Cooperation Agency). 2005. *The Study on Monitoring and Early Warning Systems for Landslides and Floods.* Cooperation Project. Municipality of Soacha, Colombia.

Johnson Controls, IFMA (International Facility Management Association), and ULI (Urban Land Institute). 2011. *Fifth Annual Global Energy Efficiency Survey.*

Kalsi, N., R. Kiran, and S. Vaidya. 2009. "Effective e-Governance for Good Governance in India." *Int. Rev. of Bus. Res. Pap* 5:212-229.

Kamal-Chaoui, Lamia, and Alexis Robert, eds. 2009. *Competitive Cities and Climate Change.* OECD Regional Development Working Paper No. 2. Paris: OECD.

Karlenzig, Warren. 2010. *Cities: The Death of Sprawl.* The Post Carbon Reader Series: Cities, Towns and Suburbs. Santa Rosa, California.

Keith, Adam and Steve Bochinger. 2009. *Satellite-based Earth Observation: Market Prospects to 2018. Euroconsult.*

Kennedy, C., S. Pincetl, and P. Bunje. 2011. "The Study of Urban Metabolism and Its Applications to Urban Planning and Design." *Journal of Environmental Pollution* 159 (8–9), 1965–1973.

Kennedy, C. A., A. Ramaswami, S. Carney, and S. Dhakal. 2009. "Greenhouse Gas Emission Baselines for Global Cities and Metropolitan Regions." Plenary paper presented at the World Bank's Fifth Urban Research Symposium, Marseille, France, June 28–30, 2009.

Kennedy, Christopher. 2011. *The Evolution of Great World Cities: Urban Wealth and Economic Growth.* University of Toronto Press.

Kennedy, Christopher, John Cuddihy and Joshua Engel-Yan. 2007. "The Changing Metabolism of Cities." *Journal of Industrial Ecology* 11 (2), 43–59.

Kennedy, Christopher, and Daniel Hoornweg. 2012. "Mainstreaming Urban Metabolism." *Journal of Industrial Ecology* 16 (6), 780–782.

Kennedy, Christopher, Julia Steinberger, Barrie Gasson, Yvonne Hansen, Timothy Hillman, Miroslav Havránek, Diane Pataki, Aumnad Phdungsilp, Anu Ramaswami, and Gara Villalba Mendez. 2009. "Greenhouse Gas Emissions from Global Cities." *Environmental Science and Technology* 43 (19), 7297–7302.

Kenworthy, J. R. 2006. "The Eco-City: Ten Key Transport and Planning Dimensions for Sustainable City Development." *Environment and Urbanization* 18 (67), 67–85.

Kessides, C. 2006. *The Urban Transition in Sub-Sub-Saharan Africa: Implications for Economic Growth and Poverty Reduction.* Washington, DC: Cities Alliance.

Labatt, S. and R.R. White. 2007. *Carbon Finance: the financial implications of climate change.* John Wiley & Sonds, Inc. Hoboken, New Jersey.

Lall, S. V., and Deichmann, U. 2012. *Density and Disasters: Economics of Urban Hazard Risk. World Bank Research Observer* 27 (1), 74–105.

Lanvin, Bruno and Anat Lewin. 2006. "The Next Frontier of E-government: Local Governments May Hold the Keys to Global Competition." In *Global Information Technology Report*, eds. World Economic Forum and INSTEAD.

Levin, S., S. Barrett, S. Aniyar, W. Baumol, C. Bliss, B. Bolin, P. Dasgupta, P. R. Ehrich, C. Folke, I. Gren, C. S. Holling, A. Jansson, B. Jansson, K. Maler, D. Martin, C. Perrings, and E. Sheshinski. 1998. "Resilience in natural and socioeconomic systems. Environment and Development." *Economics* 3:222–235.

Levine, M., Urge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., Land, S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., Rlling, J., Yoshino, H. 2007 Residential and commercial buildings, *Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, U.K. & New York, NY, U.S.A.

Licciardi, Guido. 2012. "Energy Efficiency in Historic Built Assets." In *Sustainable Low-Carbon City Development in China*, eds. Axel Baeumler, Ede Ijjasz-Vasquez, and Shomik Mehndiratta, Ch. 17. Washington, DC: The World Bank.

Litman, Todd. 2013. *Smart Growth Savings: What We Know About Public Infrastructure and Service Cost Savings, And How They are Misrepresented by Critics.* Victoria Transport Policy Institute.

MA (Millennium Ecosystem Assessment). 2005. "Urban Systems." In *Ecosystems and Human Well-being: Current State and Trends*, Washington, DC: Island Press.

MacPherson, E. G., D. J. Nowak, and R. A. Rowntree, eds. 1994. *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project*. General Technical Report NW-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

A. Mahendra, "Vehicle Restrictions in Four Latin American Cities: Is Congestion Pricing Possible?", *Transport Reviews* 28(1): 105–33.

Mann, S. 2005. "Sousveillance and cyberglogs: a 30-year empirical voyage through ethical, legal and policy issues." *Presence: Teleoperators and Virtual Environments* 14(6): 625-646.

Mansur, Erin T., and Sheila M. Olmstead. 2007. "The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations." *Journal of Urban Economics* 71 (3), 332–346.

Metz, B., O. R. Davidson, P. R. Bosch, R. Dave, and L. A. Meyer, eds. 2007. *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press.

Miller, Kathleen, and David Yates. 2006. *Climate Change and Water Resources: A Primer for Municipal Water Providers.* Awwa Research Foundation and UCAR.

Montezuma, R. 2005. "Promoting Active Lifestyles and Healthy Urban Spaces: The Cultural and Spatial Transformation of Bogota, Colombia." In *Nutrition and an Active Life: From Knowledge to Action*, ed. Wilma B. Freire, 161–182. Washington, DC: Pan-American Health Organization Regional Office of the World Health Organization.

Morcotullio, P. J., and G. Boyle. 2003. *Defining an Ecosystem Approch to Urban Management and Policy Development*. Tokyo: United Nations University Institute of Advanced Studies.

Newcombe, K. K. 1978. "The Metabolism of a City: The Case of Hong Kong." *Ambio* 7 (1), 3–15.

Newman, Peter, and Isabella Jennings. 2008. *Cities as Sustainable Ecosystems: Principles and Practices*. Island Press.

Newman, Peter, Timothy Beatley, and Heather Boyer. 2009. *Responding to Peak Oil and Climate Change*. Island Press.

OCHA (United Nations Office for the Coordination of Humanitarian Affairs). *Needs Assessment Altos de Cazucá*. Municipio de Soacha. June, 2001.

Odum, E. P. 1971. *Fundamentals of Ecology*. Philadelphia: Saunders.

OECD (Organisation for Economic Co-operation and Development). 2011a. *Cities and Green Growth*. Paris: OECD.

OECD. 2011b. Towards Green Growth. Paris: OECD.

Parry, Martin, Nigel Arnell, Pam Berry, David Dodman, Samuel Fankhauser, Chris Hope, Sari Kovats, Robert Nicholls, David Satterthwaite, Richard Tiffin, and Tim Wheeler. 2009. *Assessing the Costs of Adaptation to Climate Change: A review of the UNFCCC and Other Recent Estimates.* London: IIED.

Parry, M. L., O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, eds. 2007. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Pelissie du Rausas, Matthieu, James Manyika, Eric Hazan, Jacques Bughin, Michael Chui, Remi Said. 2011. *Internet matters: the Net's weeping impact on growth, jobs, and prosperity.* McKinsey Global Institute.

Perkins, S. 2011. Green Growth and Transport. Paris: OECD

Preston, John. 2001. "Integrating Transport with Socio-economic Activity: A Research Agenda for the New Millennium." *Journal of Transport Geography* 9 (1), 3–24.

REN21 (Renewable Energy Policy Network for the 21st Century). 2011. *Renewables 2011 Global Status Report.* Paris: REN21 Secretariat.

Republic of the Philippines. 1991. *The Local Government Code of 1991.* Manila: Government of the Philippines.

Rifkin, Jermy. 2011. *The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World.* Palgrave MacMillan.

Rode, P., G. Floater, J. Kandt, K. Baker, M. Montero Carrero, C. Heeckt, D. Smith, and M. Delfs. 2012. *Going Green: How Cities are Leading the Next Economy.* London: LSE Cities.

Rodrigue, Jean-Paul. 2013. *The Geography of Transport Systems: 3rd Edition*. Routledge, 416 pp. Hofstra University, New York, USA.

Rogers, Everett. 1983. *The Diffusion of Innovations*, 3rd edition. New York: Free Press.

Romani, M., Nicholas Stern, and D. Zenghelis. 2011. *The Basic Economics of Low-Carbon Growth in the UK*. Policy Brief. London: Grantham Research Institute on Climate Change and the Environment, Center for Climate Change Economics and Policy.

Sassen, S. 2010. "A savage sorting of winners and losers: contemporary versions of primitive accumulation." *Globalizations* 7(1): 23-50.

Satterwhaite, David, Saleemul Huq, Hannah Reid, Mark Pelling, and Patricia Romero Lankao. 2009. *Adapting to Climate Change in Urban Areas: the Possibilities and Constraints in Low-and Middle-Income Nations*. London: IIED.

Schremmer, C., and D. Stead. 2009. "Sustainable Urban Metabolism for Europe (SUME)." Paper presented at the World Bank's Fifth Urban Research Symposium, Marseille, France, June 28–30, 2009.

Sedgley, Norman, and Bruce Elmslie. 2004. "The Geographic Concentration of Knowledge: Scale, Agglomeration, and Congestion in Innovation across U.S. States." *International Regional Science Review* 27 (2), 111–137.

Sheikh, Khatibullah, and Shrinivas Rao. 2007. "Participatory City Planning in Chhattisgarh: A Civil Society Initiative." *Environment and Urbanization* 19 (2), 563–581.

Smith, R. D., and E. Maltby. 2003. *Using the Ecosystem Approach to Implement the Convention on Biological Diversity: Key Issues and Case Studies*. Gland, Switzerland, and Cambridge, UK: IUCN.

State of California Energy Commission. 2009. *Potential Targets and Benefits for Sustainable Communities Research, Development, and Demonstration Funded by the PIER Program*, by S. Pincetl and P. M. E. Bunje. Consultant report.

Stern, Nicholas H. 2010. *A Blueprint for a Safer Planet: How We Can Help Save Our World and Create Prosperity*. London: Vintage.

Stock, Wolfgang G. 2011. "Informational Cities: Analysis and Construction of Cities in the Knowledge Society." *Journal of the American Society for Information Science and Technology* 62 (5), 963–986.

Strumsky, J. Lobo, and L. Fleming. 2008. "Metropolitan Patenting, Inventor Agglomeration and Social Networks: A Tale of Two Effects." *Journal of Urban Economics* 63 (3), 871–884.

Sugar, L., C. A. Kennedy, and D. Hoornweg. 2013. "Synergies between Adaptation and Mitigation in Development: Case Studies of Amman, Jakarta, and Dar es Salaam." *International Journal of Climate Change Strategies and Management* 5 (1), 95–111.

Tchobanoglous, G., and F. Kreith. 2002. *Handbook of Solid Waste Management*, 2nd edn. New York: McGraw-Hill.

TEEB (The Economics of Ecosystems and Biodiversity). 2011. *TEEB Manual for Cities: Ecosystem Services in Urban Management*. Bonn: UNEP.

Tegen, Suzanne, and Howard Geller. 2006. *Natural Gas Demand-Side Management Programs: A National Survey*. Boulder, CO: Southwest Energy Efficiency Project.

Thaler, Richard H., and Cass R. Sunstein. 2008. *Nudge: Improving Decisions About Health, Wealth, and Happiness*, 1st edn. Yale University Press.

Transport for London. 2004. *Impacts monitoring: Second Annual Report*. London: Transport for London, Congestion Charging Central London.

UITP (International Association of Public Transport). 2010. *Public Transport in Sub-Saharan Africa: Major Trends and Case Studies*. Brussels: Trans-Africa Consortium.

ULI (Urban Land Institute). 2011. "Growing Number of Building Owners Around the World Combating Rising Energy Prices by Pursuing Energy Efficiency." Press Release, June 16.

UN (United Nations). 2008. *World Urbanization Prospects: The 2007 Revision*. New York: United Nations, Department of Economic and Social Affairs, Population Division.

UN (United Nations). 2011. Department of Economic and Social Affairs, Population Division (2011): *World Population Prospects: The 2010 Revision*, New York.

UN (United Nations). 2012. *World Urbanization Prospects: The 2011 Revision*. United Nations Publications.

UNDESA (United Nations Department of Economic and Social Affairs). 2009. *World Urbanization Prospects, The 2009 Revision*. New York: UNDESA.

UNEP (United Nations Environment Programme)/ IETC, 2002. *Melbourne Principles for Sustainable Cities*. Integrative Management Series. No 1. Osaka, Japan.

UNEP (United Nations Environment Programme). 2008b. *UNEP SBCI Members' and Partners' Update*, May 2008.

UNEP (United Nations Environment Programme). 2009a. *Buildings and Climate Change: Summary for Decision-Makers*. Paris: UNEP, Sustainable Consumption and Production Branch.

UNEP. 2009b. *Cities and Green Buildings: In the Transition to a Green Economy*. Nairobi: UNEP.

UNEP. 2011. *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*. Nairobi: UNEP.

UNEP and New Energy Finance. 2010. *Global Trends in Sustainable Energy Investment: 2010 Report Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency*. UNEP.

UN-Habitat (United Nations Human Settlement Programme). 2008. *The State of African Cities Report 2008: A Framework for Addressing Urban Challenges in Africa*. Nairobi: UN-Habitat.

UN-Habitat. 2009. *Planning Sustainable Cities: Global Report on Human Settlements 2009*. London: Earthscan.

UN-Habitat. 2010a. *Solid Waste Management in the World's Cities*. London: UN-Habitat.

UN-Habitat. 2010b. *State of the World's Cities* 2010/2011: Bridging the Urban Divide. London: Earthscan.

USGBC (U.S. Green Building Council) and Green Building Council Brasil. 2011. *Building the Green Economy from the Ground Up: Sustainable Cities and the Built Environment*. USGBC and Green Building Council Brasil.

Vandeweghe, J. R. 2007. "A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan Area." *Journal of Industrial Ecology* 11 (2), 133–144.

Vergara, Sintana E., and George Tchobanoglous. 2012. "Municipal Solid Waste and the Environment." *Annual Review of Environment and Resources* 37, 277–309.

Warren-Rhodes, K., and A. Koenig. 2001. "Escalating Trends in the Urban Metabolism of Hong Kong: 1971–1997." *Ambio* 30 (7), 429–438.

WFEO ComTech (World Federation of Engineering Organizations Committee on Technology). 2002. *Engineers and Sustainable Development*. Washington, DC: WFEO ComTech.

Wilbanks, T.J. and J. Sathaye. 2007. "Integrating mitigation and adaptation as responses to climate change: a synthesis." *Mitig. Adapt. Strat. Glob. Change* 12: 957-962.

Williams. E., R. Kahhat, B. Allenby, E. Kavazanjian, J. Kim, and M. Xu. 2008. "Environmental, social, and economic implications of global reuse and recycling of personal computers." *Environmental Science & Technology* 42(17): 6446–6454

Wolman, A. 1965. "The Metabolism of Cities." *Scientific American* 213 (3), 179–190.

World Bank. 2002. Cities on the move: A World Bank urban transport strategy review. Washington, DC: World Bank.

World Bank. 2004. *Public and Private Sector Roles in the Supply of Electricity Services*. Washington, DC: World Bank.

World Bank. 2004a. *Reforming Infrastructure: Privatization, regulation, and competition*. Washington, DC: World Bank.

World Bank. 2006. *Project Appraisal Document for the Lagos Metropolitan Development and Governance Project*. Washington, DC: World Bank.

World Bank. 2008. *Decentralization in Client Countries: An evaluation of World Bank Support 1990-2007*. Washington, DC: World Bank Independent Evaluation Group.

World Bank. 2009. *World Development Report 2009: Reshaping Economic Geography*. Washington, DC: World Bank.

World Bank. 2010a. *A City-wide Approach to Carbon Finance*. Carbon Partnership Facility Innovation Series. Washington, DC: World Bank.

World Bank. 2010b. *The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates.* The Global Report of the Economics of Adaptation to Climate Change Study. Washington, DC: World Bank.

World Bank. 2010c. *World Development Report 2010: Development and Climate Change*. Washington, DC: World Bank.

World Bank. 2010d. *Natural Hazards, Unnatural Disasters: The Economics of Effective Prevention*. Washington, DC: World Bank.

World Bank. 2011a. *Cities and Climate Change: An Urgent Agenda.* Washington, DC: World Bank.

World Bank. 2011a. *Low Carbon Cities in China*. Washington, DC: World Bank.

World Bank. 2012a. *Inclusive Green Growth: The Pathway to Sustainable Development*. Washington, DC: World Bank.

World Bank. 2012b. *Urban Risk Assessments: An Approach for Understanding Disaster and Climate Risk in Cities.* Washington, DC: World Bank.

World Bank. 2012c. *The Little Green Data Book*. Washington, DC: World Bank.

World Bank Insitute, ed. 2011. "Open Government" special issue. *Development Outreach*, September 2011.

World Commission on Environment and Development. 1987. *Our Common Future.* Oxford: Oxford University Press.

WRI (World Resources Institute). 2009. *World Greenhouse Gas Emissions in 2005.* WRI.

Zenghelis, D. 2011a. *The Economics of Network Powered Growth.* Cisco.

Zenghelis, D. 2011b. *Networked Solutions for 21st-Century Challenges: The Economics of Complexity and Scarcity, and the Role of Networked Innovation.* Cisco.

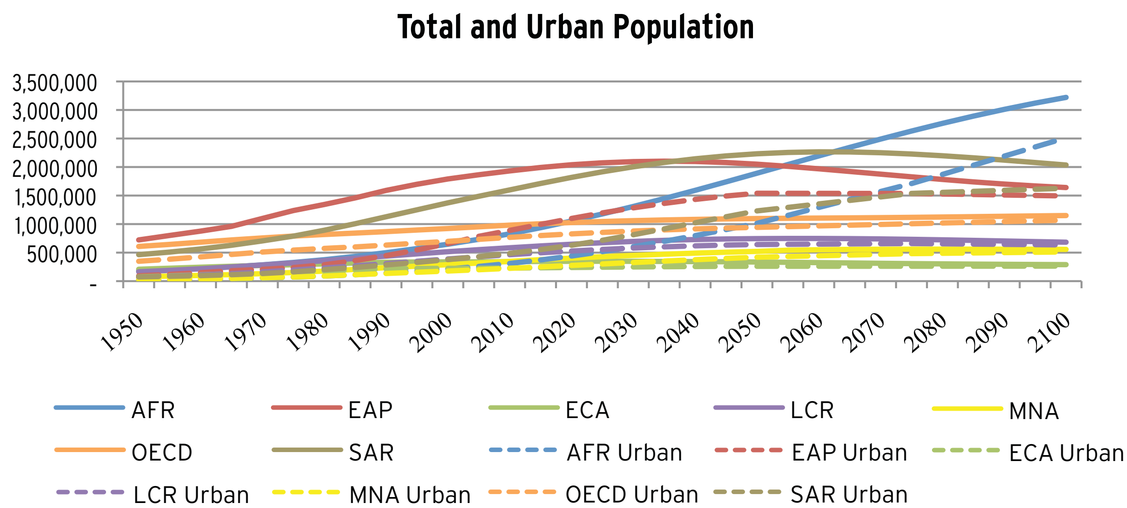
Zenghelis, C. 2011c. *A macroeconmic plan for a green recovery*. London: Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics and Policy.

Zenghelis, D. 2012. *A Strategy for Restoring Confidence and Economic Growth through Green Investment and Innovation.* London: Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics and Policy.

ANNEXES

ANNEX 1

Total and Urban Global Populations by Region



Source: Reprinted from Hoornweg and Bhada-Tata, in press.

ANNEX 2
The Green City Index Series

Urbanization has enormous environmental consequences, both global and local. Already, city-dwellers are estimated to be responsible for up to 70 percent of the world's greenhouse gas emissions (IEA 2008). Sprawling urban development consumes arable land and vital green spaces. Burgeoning numbers of city residents put pressure on water infrastructure, waste management, sewer systems, and transport networks. In order to tackle climate change, avoid lasting damage to vital ecology, and maintain the health and well-being of billions of people, solutions to these problems must be sought at the city level.

The development of such solutions, however, will depend on the knowledge generated from benchmarking urban performance and sharing of best practices across cities. Many such benchmarking initiatives and tools are emerging from community-based organizations (e.g. ICLEI), academia, and the private sector, addressing myriad aspects of urban performance and sustainability. The Green City Index is one of these benchmarking tools.

The challenge moving forward is twofold: these tools and systems need to be harmonized, and methods for data collection and analysis standardized; and city participation needs to become more universal, easier, and based on less ad hoc criteria for selection.

Conducted as a research project by the Economist Intelligence Unit and sponsored by Siemens, the Green City Index series has sought to focus attention on urban environmental sustainability. The series began with reports on cities Europe in 2009, and has since analyzed a total of more than 120 cities in the United States and Canada, Asia, Latin America, and Africa, with Australia and New Zealand. The many lessons contained in these reports are intended to help cities understand their strengths and weaknesses, and learn from each other as they debate policies and strategies to minimize their environmental footprint, while at the same time accommodating population growth and promoting economic opportunity.

Methodology: What the Green City Index Measures

The Green City Index methodology was developed by the Economist Intelligence Unit in cooperation with Siemens. Independent urban sustainability experts also advised on the methodology and provided insight into the key findings for each region. Cities were selected for their size and importance (mainly capital cities and large population or business centers). They were chosen independently, rather than relying on requests from city governments to be included or excluded, in order to enhance each index's credibility and comparability.

The Green City Index series measures cities on approximately 30 indicators across eight to nine categories, covering carbon dioxide emissions, energy consumption, buildings and land use, transport, water, sanitation, waste management, air quality, and environmental governance. About half of the indicators in each Index are quantitative, and usually these make use of data from official public sources—for example, carbon dioxide emissions per capita, water consumption per capita, recycling rates, or air pollutant concentrations. The remainder are qualitative assessments of the city's environmental policies—for example, commitments to sourcing more renewable energy, traffic congestion reduction policies, or air quality codes. The specific indicators differ slightly by geography, taking into account data availability and the unique challenges in each region. Measuring quantitative and qualitative indicators together means the indices are based on current environmental performance as well as future intentions to be greener.

Each city received an overall index ranking and a ranking for each individual category. The results

European Green City Index Methodology

Note: The European Green City Index analyzed cities on the basis of 16 quantitative and 14 qualitative indicators in eight categories. This basic methodology was adapted for the other indices, taking into account data availability and regional environmental challenges.

were presented numerically (for the European index and the U.S. and Canada index) or in five performance bands, from "well above average" to "well below average" (for the Asian, Latin American and African indices). Bands were used in regions where levels of data quality and comparability did not allow for a detailed numerical ranking.

The Index Leaders: Wealthier and Good with Governance

The leading cities across the regional Indices had several factors in common. Wealth was a clear driver; cities with more money can invest in infrastructure and set aside more generous budgets for environmental oversight. A second key factor was governance—the city's commitment to robust and innovative environmental policies across all categories, from energy to air quality. Another driver was consistency. Cities doing very well overall didn't necessarily place number one for each of the eight or nine categories, but were usually near the top across the board. This suggests that successful cities are following a holistic approach to environmental management (see key lessons, below).

Autonomy and a Unified Strategy Required: Key Lessons from the Index Series

In search of a holistic approach. Top-performing cities take a holistic approach to environmental problems, recognizing that performance in one category, such as transport, is linked to success in others such as air quality. These cities often have dedicated environmental departments and structured communication between departments with different responsibilities (for example, water, waste management, and transport). One of the best examples from the series is Curitiba. As early as the 1960s, faced with rapid population growth, city officials implemented proposals to reduce urban sprawl, create pedestrian areas and provide low-cost rapid transit. By the 1980s, the urban plan involved integrated initiatives that addressed issues such as the creation of green areas, waste recycling and management, and sanitation.

Boston, New York, San Francisco, and Seattle all scored well in the U.S. and Canada Index, largely because they have integrated their environmental programs into wider development strategies that simultaneously revitalize their economies and make urban areas more livable. These cities stand out as examples pointing the way forward. In many cities around the world, different departments manage different aspects of sustainable urban development, with no one setting the overall strategy.

Cities need more autonomy. One important driver for urban sustainability is autonomy at the municipal level. Top-performing cities such as Singapore and Hong Kong have the authority to set their own environmental policies and the funding to implement them. This autonomy allows local officials to set their own priorities and respond more effectively to local needs without depending on a more removed national government, which may have competing priorities. Unfortunately, weak local governments are a widespread problem, especially in the developing world. In Africa, decentralization of power from the national to the local level is crucial for effective planning, but there is a trend towards national governments taking even more authority over decisions about cities. Strong local governments were one of the main reasons for the relatively high ranking of South African cities, as well as Accra.

The Tipping Point: Income and Environmental Performance. In most regions there was a connection between a city's wealth (as measured by GDP per capita) and its performance in the Green City Index; the higher the income, the better the result. Especially in developing cities, rising incomes initially cause higher levels of resource consumption, waste, and pollution. The Asian Index shows that only when GDP per capita rises above approximately $20,000 per person is there a boost for the environment—a tipping point at which wealthy residents start to consume relatively less water, generate less waste, and produce less carbon. Osaka, Singapore, Taipei, and Tokyo all showed evidence of this phenomenon in the Asian Index. Generally speaking, as city residents reach a certain level of wealth, they tend to acquire a growing awareness of environmental issues. They begin to support policies that limit consumption in favor of promoting urban sustainability and improved livability.

Not only for the rich: What developing cities can achieve. Although wealth undoubtedly plays a role in environmental performance, the Green City

Top Cities in Each Region*

European Green City Index (2009) Top five cities by rank (of 30 total)	**US & Canada Green City Index (2011)** Top five cities by rank (of 27 total)	**Latin American Green City Index (2010)** All cities placing above average (of 17 total)	**Asian Green City Index (2011)** All cities placing above average (of 22 total)	**African Green City Index (2011)** All cities placing above average (of 15 total)
1st. Copenhagen	1st. San Francisco	Well above average: Curitiba	Well above average: Singapore	Well above average: none
2nd. Stockholm	2nd. Vancouver	Above average: Belo Horizonte Bogotá Brasília Rio de Janeiro São Paulo	Above average: Hong Kong Osaka Seoul Taipei Tokyo Yokohama	Above average: Accra Cape Town Casablanca Durban Johannesburg Tunis
3rd. Oslo	3rd. New York City			
4th. Vienna	4th. Seattle			
5th. Amsterdam	5th. Denver			

Source: Green Cities Index data.

Note: Cities in Europe, the United States, and Canada were ranked numerically. Cities in Asia, Latin America and Africa were ranked in five bands, from "well above average" to "well below average."

Index series shows that low-cost actions can have big benefits. Delhi in particular shows that those less well off can adopt policies and shape attitudes towards sustainability. The city had one of the lowest levels of GDP per capita in the Asian Index, at an estimated $2,000. Yet it still achieved an average overall rating, with a strong result in the waste category, where it ranked above average. This is in part because of what has been called Delhi's "traditional culture of careful consumption"—a tendency to reuse and recycle as much as possible. Building on this, however, Delhi has introduced advanced policies, including one of the more robust strategies in the index to reduce, reuse, and recycle waste, demonstrating just how much can be achieved with limited resources and popular support. Indeed, public engagement in policies is often a prerequisite for successful policies in any city, developed or developing. In the European index, there was a correlation between levels of civic engagement and environmental performance.

Low-income cities can also look to international agencies to finance environmental goals. One example is Vilnius, ranked 13th in the European index, making it the best-performing city in Eastern Europe and among the low-income cities in the European Index. The city took advantage of funding from the World Health Organization Healthy Cities project to promote the use of cycling and public transport. It also drew on European Union funds to improve its water supply and treatment network.

Conclusion: Apples to Apples—the Challenge of Collecting Comparable Data Worldwide

Data collection was a challenge to some extent in all of the regions covered by the Green City Index series. Many cities diligently collect key environmental data and update it regularly. The challenge comes when comparing information across cities. For example, in Europe, one of the more accessible regions in terms of environmental metrics, around one-third of the 30 cities in the Index did not measure the full amount of energy consumed in their city or the associated carbon dioxide emissions. In many cases, the Economist Intelligence Unit made statistical estimates (extrapolating from partial data or national figures) to fill data gaps. Overlapping jurisdictions within regions was a challenge too—data for energy, transport, or air quality may have been collected at the metropolitan level in some jurisdictions, the municipal level in others, or in some cities not at all. A related problem was that urban agglomerations, which need to be integrated into municipal planning for sustainability policies to be effective, often lacked a single data source. In addition, in developing cities, acquiring data on informal settlements, which have huge environmental impacts, proved especially difficult.

Overall, across the Green City Index regions, there were very few instances in which one single data point—carbon dioxide emissions per capita, for example—was measured and reported in the same way in each region. This lack of comparability is a call to action in itself. Establishing a set of agreed-upon global metrics for urban carbon emissions, energy consumption, air quality, and other key environmental performance indicators would be a major step towards providing policymakers with a comprehensive assessment of their cities' current environmental footprint. More importantly, a consistent set of sustainability indicators would help reveal the most appropriate municipal policies and efficient investments to improve green performance.

More information on the Green City Index: www.siemens.com/greencityindex

ANNEX 3
Global City Indicators Facility (GCIF)

The Global City Indicators Facility (GCIF) is positioned to be the definitive and authoritative compilation of validated, self-reported, worldwide urban data. For the first time, a database hosting globally comparative city data based upon a globally standardized methodology provides a platform for comparative global research. This Facility also provides a solid base for evidence-based policy and management at the local level to build more sustainable cities. Headquartered in Toronto, the GCIF is rapidly becoming a global leader and centre of excellence on globally standardized city metrics. As cities worldwide increasingly take centre stage in the sustainable economic development and prosperity of nations, the need for globally comparable data and knowledge on cities has never been greater.

The GCIF hosts a standardized system of global city indicators with support from the World Bank, the University of Toronto, the Government of Ontario, Canada, and a worldwide network of participating cities. Currently, 115 indicators across more than 200 cities are collected annually. GCIF member cities are representative of all regions of the world, and the GCIF aims to increase membership to 250 cities by 2012, 500 cities by 2015, and 1,000 cities by 2020. The GCIF indicators are undergoing ISO review for standardization.

To date, no city data conforms to a standardized methodology that can ensure sound comparative urban research for global learning on sustainable cities. The GCIF provides cities with a free, web-based system to enter city data, track progress over time and facilitate capacity building and knowledge sharing. Globally comparative data strengthens cities' policy leverage and performance management through evidence-based decision making. Citizens and businesses are empowered through transparent access to accurate performance information about their cities and other cities in a comparative global framework. The GCIF also provides support for international development agencies' provision of validated, worldwide urban data.

The mission of the GCIF is to improve knowledge on cities worldwide through the collection, organization, and analysis of urban information, thereby assisting cities globally in evidence-based policy, planning and management, and comparative learning for sustainable cities.

The GCIF strives to

- improve the capacity for researchers to undertake comparative analysis of cities globally;
- help city leaders make informed, evidence-based decisions;
- provide globally comparative city data for senior levels of government responsible for economic productivity and global competitiveness;
- empower the business sector and citizens through access to accurate performance information about their cities and other cities in a comparative global framework;
- support international development agencies in the provision of validated, worldwide urban data;
- provide a standardized tool for cities to make global comparisons and track performance over time; and
- improve understanding of cities in key sectors including finance, sustainability, climate risk, transport, emergency services, water, waste management, housing and all city services, diversity and quality of life, from the local to global scale;

Website

The GCIF website (www.cityindicators.org) provides an uncomplicated relational database for cities to input, manage, and update indicators for their city. It provides member cities with a tool to measure progress toward achieving performance goals, access information about peer cities globally, and share information as well as expertise. The website also increases transparency in terms of providing the business sector and the public at large, as well as the international development community, with accurate performance information about their cities, and generates essential, baseline urban data for the academic community. In addition, the GCIF website is a tool for senior levels of government responsible for economic productivity and global competitiveness. The GCIF's online presence facilitates the dissemination of not only the indicators data, but also research documents, global reports, policy briefs, and other publications.

Indicators

The GCIF Indicators are structured around 20 themes and measure a range of city services and quality of life factors. City performance relative to each of these themes is measured by a suite of indicators that collectively tell a story. Recognizing the differences in resources and capabilities between world cities, the overall set of indicators has been divided into "core" indicators, which all member cities are expected to report on, and "supporting" indicators, which all cities would be encouraged, but not expected, to report on. The current set of global city indicators was selected based on a pilot phase with nine cities and from significant input from the current member cities, ensuring that these indicators reflect city information needs, interests, and data availability.

For more information, please contact the Global City Indicators Facility at:

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ANNEX 4
Summary of Measures Adopted in Selected Cities

The following table summarizes measures adopted in a sample of local Climate Action Plans, divided by continent and type of instrument. The measures are listed in the Urban Transport/Climate Action Plans of the cities that in *Urban Transport and Climate Change Action Plans: An Overview* (GIZ 2009)

Instruments		Africa	Asia						Australia & Pacific			Europe					
		Johannes-burg	Beijing	Hong Kong	Seoul	Tokyo	Singapore	Mumbai	Melbourne	Sydney	Auckalnd	Frankfurt (Main)	Hamburg	Munich	Brussels	Copenh-agen	London
Planning	Land Use Panning	✓			✓		✓		✓		✓			✓			
Planning	Public Transport	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Planning	Non-Motorised Modes		✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Regulatory	Physical restraint Measures																
Regulatory	Traffic management Measures	✓	✓		✓		✓	✓	✓	✓		✓	✓				✓
Regulatory	Regulation of Parking Supply		✓					✓			(✓)	✓		✓			
Regulatory	Low Emission Zone		✓									✓	✓	✓		✓	
Regulatory	Speed Restrictions										✓	✓					
Economic	Road Pricing						✓				(✓)		(✓)			(✓)	✓
Economic	Tax Incentives			✓			✓										
Economic	Parking Pricing		✓								(✓)	✓	(✓)				
Information	Public Awareness Campaigns	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Information	Stakeholder conferences	✓				✓					✓			✓			✓
Information	Driver Training / Eco Driving					✓			✓								✓
Tech-nology	Cleaner Technology	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			(✓)	✓
Research	Emission monitoring, Establishing a reliable database	✓			✓												

Instruments		Europe (continued)			North America										Latin & South America	
		Madrid	Stockholm	Vienna	Boulder	Chicago	Denver	Houston	Los Angeles	New York	Montreal	Ottawa	Toronto	vancouver	Mexico City	Sao Paulo
Planning	Land Use Panning	✓		✓	(✓)	✓	✓			✓	✓	✓				✓
Planning	Public Transport	(✓)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Planning	Non-Motorised Modes	(✓)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Regulatory	Physical restraint Measures														✓	✓
Regulatory	Traffic management Measures		✓	✓				✓		✓	✓	✓				✓
Regulatory	Regulation of Parking Supply	✓		✓						✓	✓	✓				
Regulatory	Low Emission Zone															
Regulatory	Speed Restrictions		✓	✓							✓					
Economic	Road Pricing		✓							(✓)						
Economic	Fuel Tax Incentives															
Economic	Parking Pricing										✓	✓				
Information	Public Awareness Campaigns	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Information	Stakeholder conferences	✓		✓				✓	✓					✓		
Information	Driver Training / Eco Driving	✓	✓	✓	✓											
Tech-nology	Cleaner Technology	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Research	Emission monitoring, Establishing a reliable				✓			✓	✓		✓					

Source: GIZ (2009)

ANNEX 5
Sustainable Infrastructure Rating System

Envision™ System Establishes Holistic Framework for Rating Sustainability of Infrastructure Projects

The environment for infrastructure has become increasingly challenging as demands for energy and water resources climb. The professionals who design and build these projects face a tall order in the years ahead: satisfying ever-growing demand, while at the same time responsibly addressing the potential effects caused by climate change and the increasing demand for resources by integrating sustainable techniques in infrastructure design and construction. The civil infrastructure that best meets those challenges—and that can serve as an example to others—can now be rated by Envision™, a rating system developed to gauge infrastructure sustainability.

Envision™ is the product of a strategic alliance and collaboration of several organizations, including the Institute for Sustainable Infrastructure (ISI), a nonprofit organization co-founded by the American Public Works Association, the American Society of Civil Engineers, and the American Council of Engineering Companies; and the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design.

To meet the serious infrastructure challenges society currently faces, the Envision™ rating system is designed to be used as an integrated educational and resource library, as well as a project-assessment system. The assessment recognizes the need to stretch the traditional design boundaries. Infrastructure projects should be judged not only by how they are delivered, but by how long they last, accounting for durability, flexibility, and utility of the constructed works.

The new sustainable infrastructure rating system will evaluate and grade infrastructure projects, recognizing those that provide progress and contributions for a sustainable future. Its purpose is to foster a necessary and dramatic improvement in the performance and resilience of physical infrastructure across all dimensions of sustainability: economic, social, and environmental.

Designers, infrastructure decision makers, and the public currently face a proliferation of sustainability rating tools, most of which focus on the performance of a particular infrastructure element, rather than its contribution to the system in which it resides. To address this, Envision™ instead establishes a holistic framework for evaluating and rating infrastructure projects against the needs and values of the community. It ensures that the sustainability of tomorrow's infrastructure is assessed accurately by considering the entire life cycle of projects at a systems level. Envision™ not only asks, "Did we do the project right?" but also, "Did we do the right project?"

In addition, Envision™ raises the bar on sustainability performance by recognizing efforts that replenish and restore natural resources and ecosystems, and by evaluating infrastructure throughout its full life, with ratings for design and planning, construction, operations, and decommissioning. The initial release of Envision™ addresses the design and planning phase, with subsequent phase ratings to follow.

Within each phase, sustainability objectives are organized in three tiers: categories, subcategories, and assessment objectives called credits. Sixty credits are arranged into five primary categories that represent primary attributes of sustainable infrastructure solutions: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. Each of the 60 credits is explained in a detailed guidance manual and includes the credit name, intent, levels of achievement, description, explanation on how to advance to higher achievement levels, evaluation criteria and documentation, sources, and related credits. By meeting objectives within a credit, projects earn points toward their rating score. The achievement of points within the credit is scaled to five levels to ensure all efforts to achieve sustainability are rewarded proportionally.

Recognition of the challenges and complexity of achieving sustainability is a necessary step in improving infrastructure development. The purpose of Envision™ is to initiate a systemic change that improves not only project performance, but the mindsets of designers, project owners, and decision makers—to transform the way infrastructure is designed, built, and operated.

ANNEX 6
Engineering for Sustainable Development

The engineering community has myriad important roles to play in improving human living standards and protecting and restoring the environment. In particular, engineers have already taken steps in support of the sustainability goals articulated in the Rio Summit in 1992. Moving forward, the World Federation of Engineering Organizations has identified ways in which the profession can more effectively contribute to sustainable development in the future.

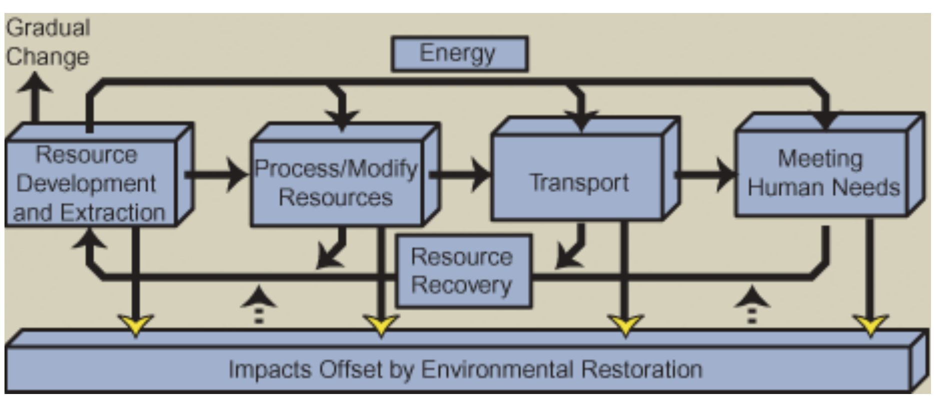
Engineers approach sustainability in terms of the systems they design and build. A sustainable system is one that is either in equilibrium, or one that changes slowly at a tolerable rate. This concept is based on the characteristics of natural ecosystems, which consist of nearly closed resource and energy loops that change slowly and are resilient to external shocks.

A closed-loop ecosystem model has been proposed to illustrate the roles of engineers in every phase of a human ecosystem that mimics natural systems (see Figure 1).

Engineers can

- extract and develop natural resources in closed-loop, low-impact systems;
- process and modify resources efficiently, and with minimal adverse environmental impacts throughout full product life cycles;
- design and build transportation infrastructure to improve quality of life and meet human needs;
- meet the needs of consumers by designing useful products and services;
- recover resources and minimize waste by designing products for reuse and recycling;
- produce and distribute non-fossil energy and design energy-efficient products; and
- offset the impacts of industrial activity by designing programs to clean up and reuse old waste sites, along with other forms of environmental restoration.

FIG. 1 Illustration of Engineers' Definition of a Sustainable System



Source: Reprinted from WFEO ComTech (2002).

As the primary designers of the world's infrastructure, engineers build projects and deliver services whose ultimate purpose is to meet human needs. Increasingly, however, addressing the environmental impacts of these projects has become an equally important role. Given the broad range of issues and sectors in which engineers work, they can contribute significantly to achieving sustainability goals along the entire chain of modern production and consumption.

There are approximately 15 million engineers in the world today, and they encompass several disciplines (civil, environmental, mechanical, electrical, chemical, industrial, agricultural, mining, petroleum, and computer engineers). Engineers are involved with two kinds of projects:

1. They design and build projects that meet basic human needs (potable water, food, housing, sanitation, energy, transportation, communication, resource development, and industrial processing).

2. They solve environmental problems (create waste treatment facilities, recycle resources, clean up and restore polluted sites, and protect or restore natural ecosystems).

Both types can be implemented with sustainable development as a primary goal, by planning and building projects that preserve natural resources, are cost-efficient, and support human and natural environments. In each phase of the ecosystem model shown in Figure 1, engineers fulfill several functions and can actively contribute to sustainable development. Some examples of these roles:

- Developing and extracting natural resources
- Water resource planning of all kinds, including dams, irrigation systems, and wells
- Designing tree plantations and managing forests
- Improved land-use planning to protect natural resources from the impact of urban sprawl

Processing and Modifying Resources

In the past, many industries generated waste products that were toxic and not easily degraded under natural conditions. In the last 100 years, this has led to environmental pollution and new laws and regulations to help protect the environment. Many industries are now making major changes in the ways they use raw materials to produce products. By reducing their waste to a minimum, many are finding that resource-efficient processing leads to increased profits.

Engineers play the following roles in processing and modifying resources:

- They change industrial processes to reduce the use of energy, resources and waste.
- They consider the total input and output of operations over their complete life cycles.
- They apply the principles of industrial ecology—for example, creating eco-industrial parks, where several industries are co-located and waste products are used as the raw materials for other industries.

Transportation

Engineers are at the forefront of developing transportation systems, including designing and building all-weather roads and highways, designing more efficient engines and transportation vehicles, and constructing railroads and high-speed rail systems.

In the future, engineers will design these transportation systems that

- are more energy efficient and create fewer adverse environmental impacts;
- encourage sound urban and rural planning with less urban sprawl; and
- have longer-lived facilities that can be maintained at lower costs.
- Meeting Consumer Needs

As the rapid urbanization of the developing world continues in the coming decades, the engineering profession will have a growing responsibility to help provide shelter, infrastructure, and other resources to this population. The roles of engineers in meeting human needs include:

- Creative land planning and development to minimize negative environmental impacts
- Designing housing and commercial buildings, streets, utility lines, public transportation, and other infrastructure
- Reducing the risks of damage and loss of life from natural hazards

Resource Recovery and Reuse

For sustainable development to be possible, human activities will have to be redesigned to maximize resource efficiency. Engineers can assist in this process in several ways:

- Design better solid waste collection and storage facilities.
- Improve methods to collect and reuse construction materials from the built environment.
- Recover, reuse and remanufacture by-products from industrial processing.

Environmental Restoration

Some environmental pollution is inevitable in the future, resulting from resource extraction, industrial processing and transportation, and wastes generated by humans. The impacts of residual wastes should be offset by a variety of environmental restoration projects, such as:

- Treating and restoring old industrial waste sites
- Restoring the ecology of lakes and wetlands
- Renewing aging urban areas in large cities

Energy Production and Use

The long-term effects of increased fossil energy use, with attendant greenhouse gas emissions, will produce major changes in the Earth's climate. One of the greatest engineering challenges will be to develop less carbon-intensive energy sources, while simultaneously reducing total energy consumption. The roles of engineers in energy production may include the following:

- More efficiently extracting and processing remaining petroleum and gas reserves
- Improving the efficiency of electric power generation, transmission, and distribution
- Expanding the use of renewables (hydroelectric, solar, geothermal, wind, and biomass energy).

Engineers can also play a role in conserving and reducing the use of energy in the following ways:

- Designing energy-efficient buildings and industrial processes
- Designing more efficient automobiles and public transportation systems

The engineering profession will be called upon to fulfill these and many other roles in the design, building, operation and maintenance of sustainable cities.

Accomplishments of the Profession Since the First UN Conference on Environment and Development

Following the Rio Summit in 1992, a group of engineers made a systematic analysis of the conference's primary action document, Agenda 21. They found that of the 2,500 issues in Agenda 21, 1,700 have engineering or technical implications, and at least 241 appeared to have major engineering implications. In the 20 years since the Rio Summit of 1992, progress has been slow but encouraging. The accomplishments include the following:

- International engineering organizations formed a new entity, the World Engineering Partnership for Sustainable Development (WEPSD). Engineering societies also formed environmental committees at both national and global levels to consider environmental issues.
- Many engineering organizations developed environmental policies, codes of ethics, and sustainable development guidelines.
- Engineering groups contributed to the creation of the Earth Charter.
- Educational programs were started to introduce sustainable development concepts to engineering students and practicing engineers.
- Industrial processes were improved to reduce the use of resources in manufacturing and to reduce waste products.

Future Goals

Engineers believe that many of the challenges of sustainable urban development can be solved by using existing knowledge, technology, and experience, combined with new innovations. For the engineering profession, these innovations will be in the following areas:

- *Sharing information.* Creating a comprehensive program to identify and provide the information that engineers in developing countries need to meet energy requirements, as well as other basic human needs like food, health services, and infrastructure.
- *Global education programs.* Expanding global educational programs on sustainable development for students and practicing engineers, in order to make sustainable development more understandable and easier to apply to real-world engineering projects.
- *Engineers as environmental generalists.* Encouraging more engineers to become environmental generalists to broaden perspectives in engineering and equip them to assume leadership roles in education, industry and government.
- *Engineers in decision making.* Becoming actively engaged in the full range of decision making processes in addition to designing and imple-

menting projects. Engineers can help direct the course of important projects—and foster sustainable development—by involving themselves in all stages of a project's decision making.

- *Environmental impacts and costs.* Improving methods for identifying and considering all of a project's environmental costs and impacts throughout a project's life cycle. Practical approaches should be developed that would alter conventional accounting practices to factor in the direct and indirect environmental costs of a facility through its life cycle of operations.

- *Direct assistance programs.* Creating programs to provide hands-on help, share knowledge and provide assistance on technically viable, commercially feasible, and socially sustainable projects in developing countries. For example, engineering firms that have extensive experience should be encouraged to partner with engineers in less developed countries. This teaming, built into project requirements, could be an effective way to increase the capabilities of local engineering firms and practitioners.

- *Policy, principles, and partnerships.* Supporting well-crafted policies and creative applications of engineering principles, and committing to partnerships with social and physical scientists and health and medical professionals. Engineers should move beyond their disciplines to evaluate alternatives and to effect policy changes toward sustainable development. They should develop partnerships with other design professionals, economists, and social, environmental, and physical scientists to arrive at environmentally sustainable and socially equitable solutions. This means that engineers, along with other technical professionals, should actively engage in the full life cycle of decision making processes, including the interdisciplinary process of building the evaluation and decision framework and the infrastructure to realize the required sustainable future.

ANNEX 7
Data Requirements for Abbreviated Urban Metabolism Studies

Quantity	GCIF	Required for GHG calculation	Notes
INFLOWS			
Food		√*	Standard climate data
Water (imports)	√	√*	
Water (precipitation)			Primarily cement, aggregates, steel
Groundwater abstraction	√	√*	
Construction materials		√*	
Fossil fuels (by type)		√	Standard climate data
Electricity	√	√	Example nutrient
Total incoming solar radiation			
Phosphorus			
PRODUCED			
Food		√*	
Construction materials		√	Cement and steel production
STOCKS			
Construction materials			In the building stock
Phosphorus			
Landfill waste		√	Accumulated
Construction/demolition waste			
OUTFLOWS			
Exported landfill waste		√	
Incinerated waste		√	Air emission plus accumulated mass
Exported recyclables			
Wastewater		√	
Phosphorus			
SO2			
NOx			
CO			
Volatile organics			
Particulates			
Methane		√	
Ozone		√+	
Black carbon		√+	

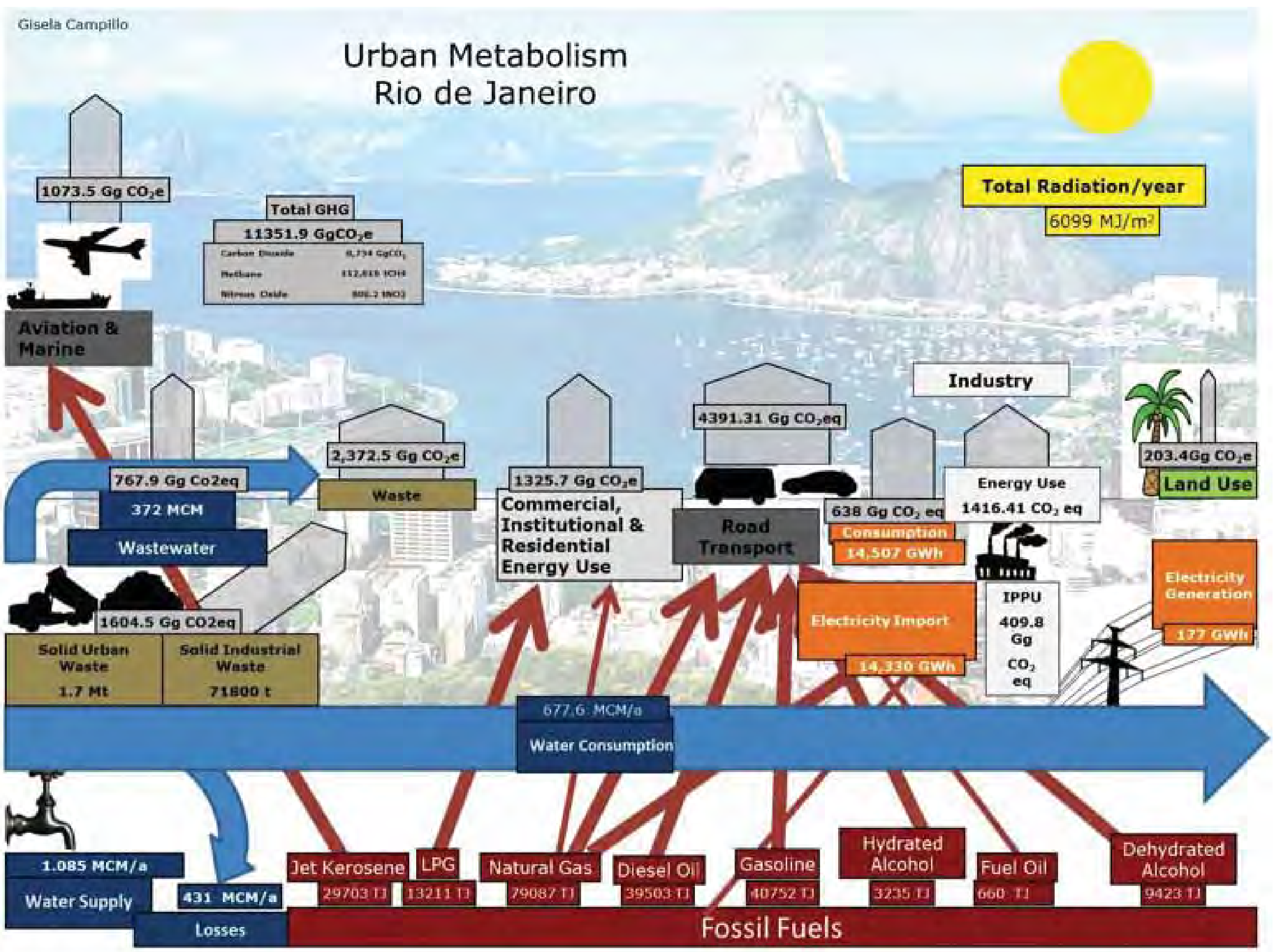
GCIF=Global City Indicators Facility
*has upstream (embodied) greenhouse gas (GHG) emissions
+typically omitted from greenhouse gas calculations due to difficulty in estimation

Source: Kennedy and Hoornweg (2012).

ANNEX 8
Material Flows in Cities

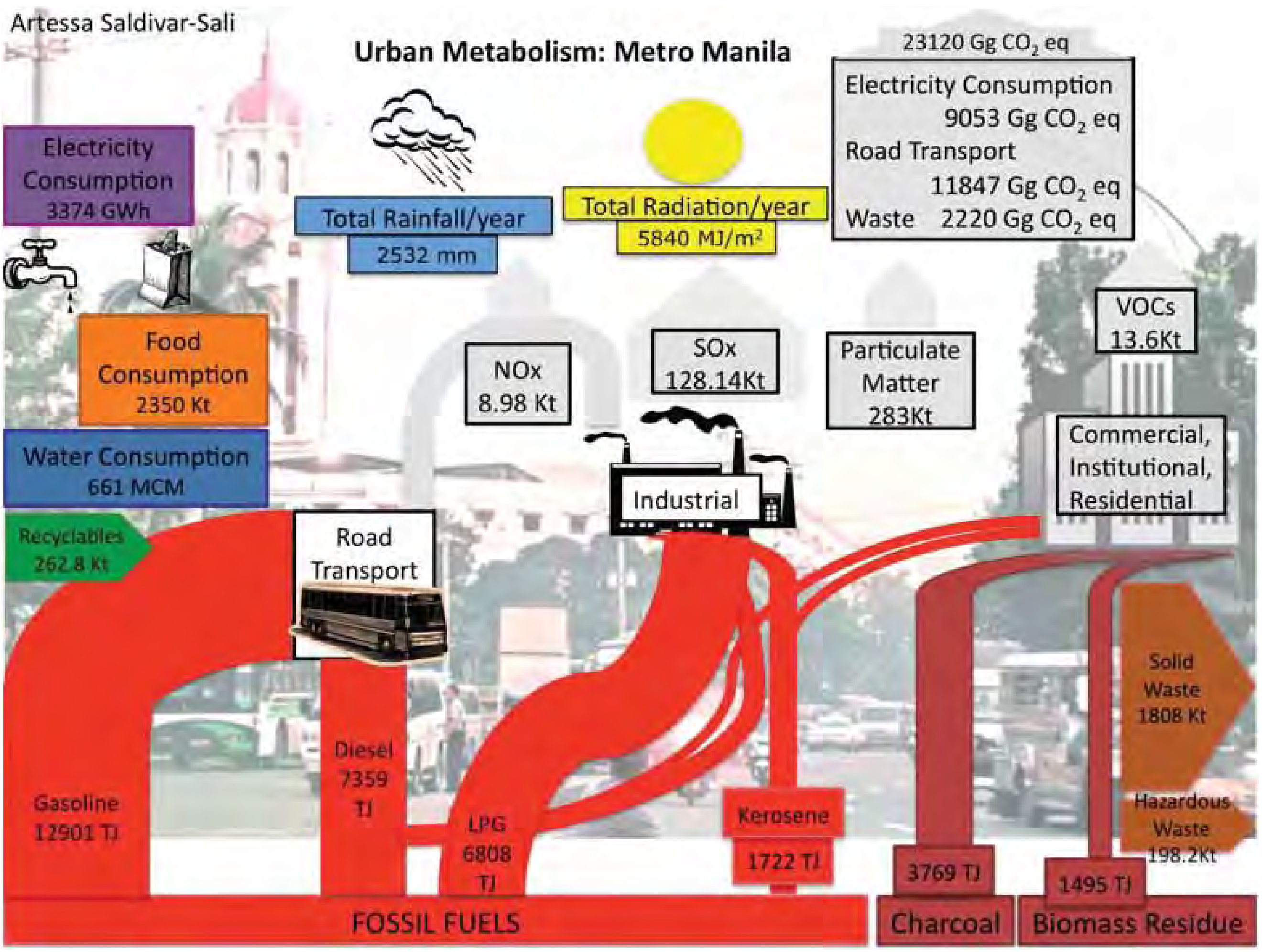
The Urban Development and Resilience Unit of the World Bank has carried out Abbreviated Urban Metabolism Studies in a number of cities and metropolitan areas, including Rio de Janeiro, Metro Manila, São Paulo, and Amman. The format for presenting the material flow diagrams has not yet been standardized, but some examples are included below. All data are from national and sub-national statistical agencies and local government units, and annual values are shown.

FIG. 1
Abbreviated Urban Metabolism Diagram for Rio de Janeiro, Brazil



Source: Gisela Campillo

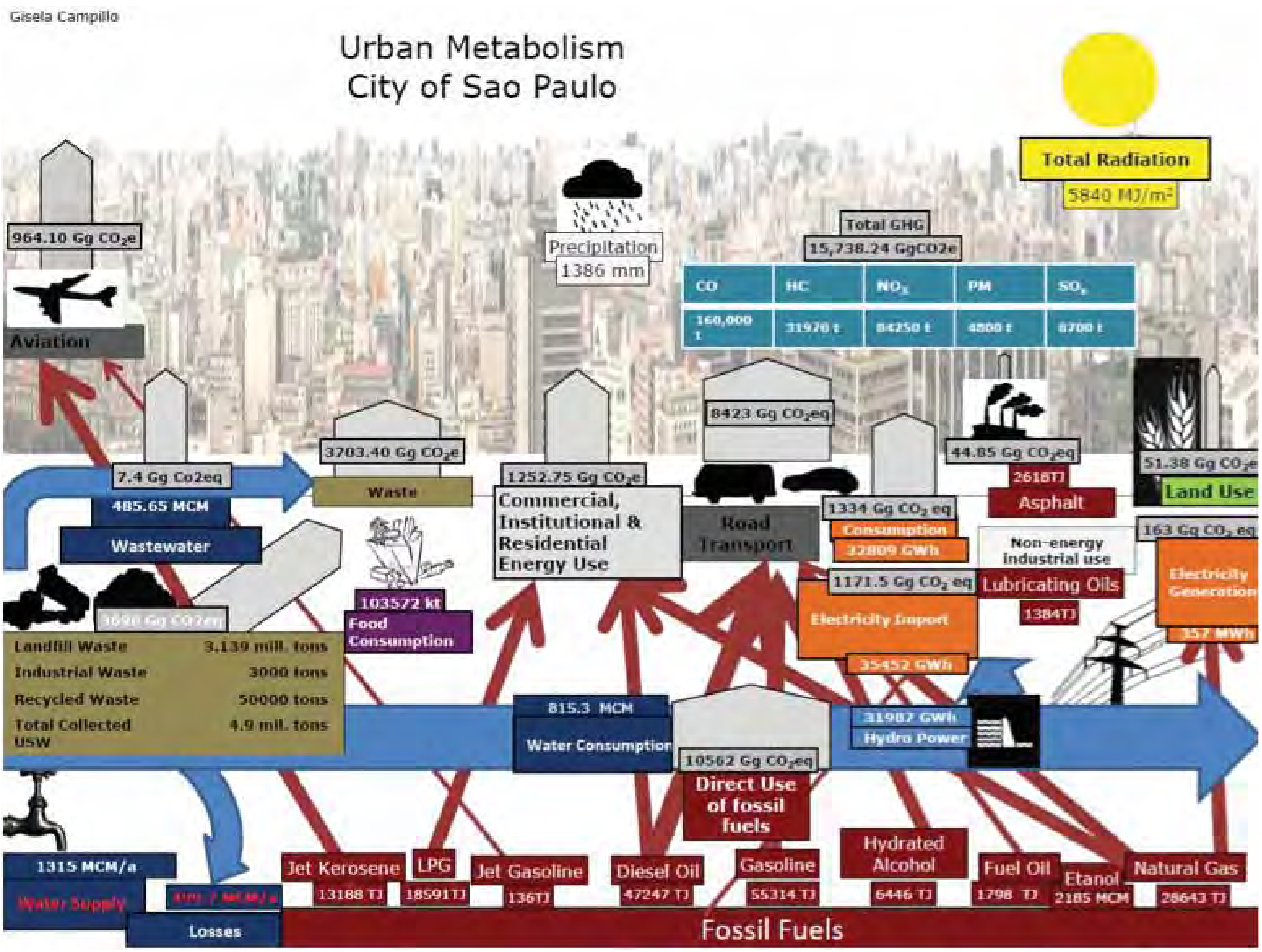
FIG. 2
Abbreviated Urban Metabolism Diagram for Metro Manila, the Philippines



Source: Artessa Saldivar-Sali

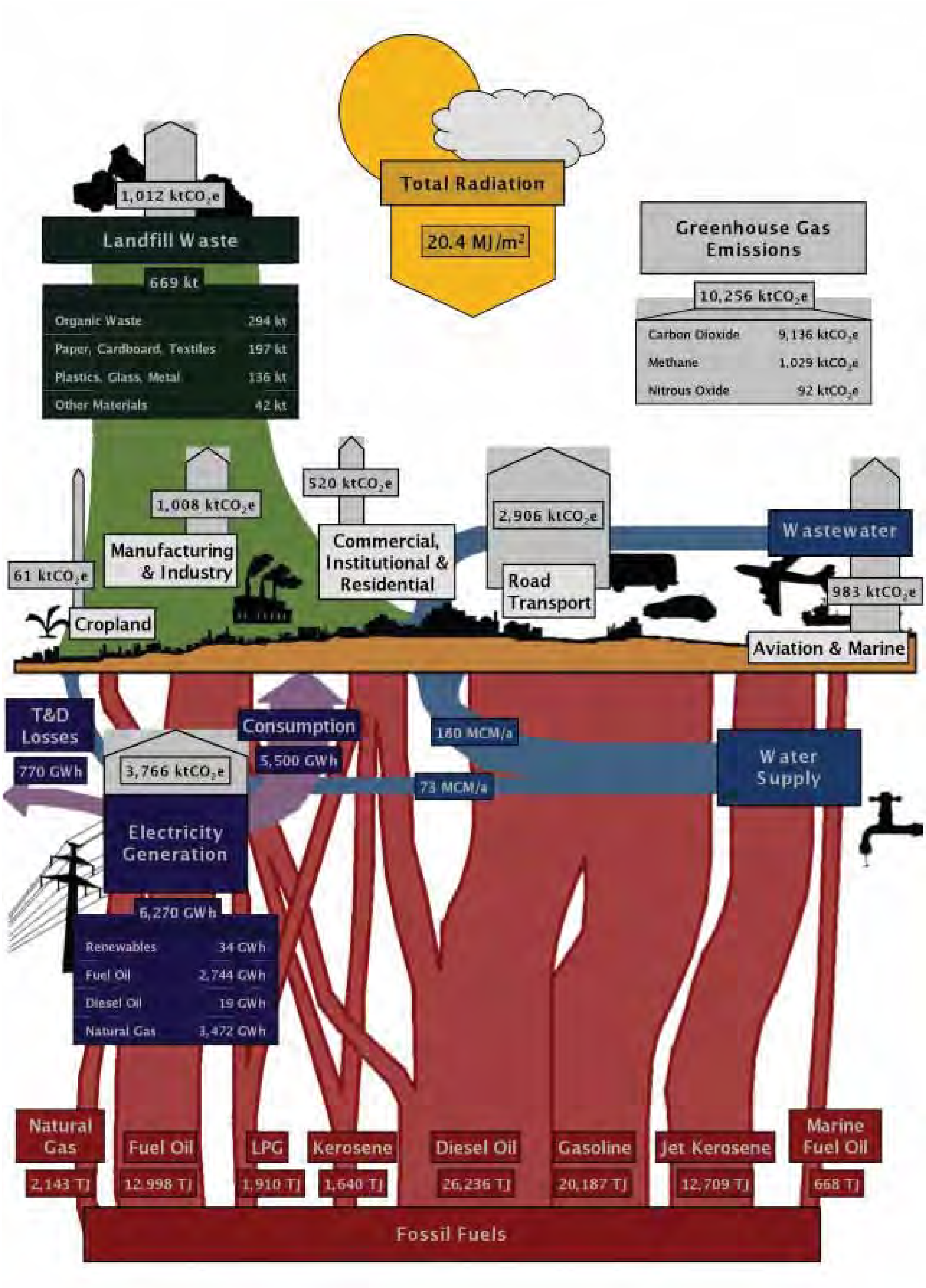
FIG. 3

Abbreviated Urban Metabolism Diagram for São Paulo, Brazil



Source: Gisela Campillo

FIG. 4
Abbreviated Urban Metabolism Diagram for Amman, Jordan



Source: Lorraine Sugar

ANNEX 9

The World's 100 Largest Urban Areas (as of 2006)

Rank	Urban Area	Country	World Bank Income Group	Population in 2006 (millions)
1	Tokyo	Japan	High income	35.53
2	Mexico City	Mexico	Upper-middle income	19.24
3	Mumbai (Bombay)	India	Lower-middle income	18.84
4	New York	USA	High income	18.65
5	São Paulo	Brazil	Upper-middle income	18.61
6	Delhi	India	Lower-middle income	16
7	Calcutta	India	Lower-middle income	14.57
8	Jakarta	Indonesia	Lower-middle income	13.67
9	Buenos Aires	Argentina	Upper-middle income	13.52
10	Dhaka	Bangladesh	Low income	13.09
11	Shanghai	China	Upper-middle income	12.63
12	Los Angeles	USA	High income	12.22
13	Karachi	Pakistan	Lower-middle income	12.2
14	Lagos	Nigeria	Lower-middle income	11.7
15	Rio de Janeiro	Brazil	Upper-middle income	11.62
16	Osaka-Kobe	Japan	High income	11.32
17	Cairo	Egypt	Lower-middle income	11.29
18	Beijing	China	Upper-middle income	10.85
19	Moscow	Russia	Upper-middle income	10.82
20	Metro Manila	Philippines	Lower-middle income	10.8
21	Istanbul	Turkey	Upper-middle income	10
22	Paris	France	High income	9.89
23	Seoul	South Korea	High income	9.52
24	Tianjin	China	Upper-middle income	9.39
25	Chicago	USA	High income	8.8
26	Lima	Peru	Upper-middle income	8.35
27	Bogotá	Colombia	Upper-middle income	7.8
28	London	UK	High income	7.61
29	Tehran	Iran	Upper-middle income	7.42
30	Hong Kong	China	High income	7.28
31	Chennai (Madras)	India	Lower-middle income	7.04
32	Bangalore	India	Lower-middle income	6.75
33	Bangkok	Thailand	Upper-middle income	6.65
34	Dortmund-Bochum	Germany	High income	6.57
35	Lahore	Pakistan	Lower-middle income	6.57
36	Hyderabad	India	Lower-middle income	6.34
37	Wuhan	China	Upper-middle income	6.18
38	Baghdad	Iraq	Lower-middle income	6.06
39	Kinshasa	Congo, Dem. Rep.	Low income	5.89
40	Riyadh	Saudi Arabia	High income	5.76
41	Santiago	Chile	Upper-middle income	5.7
42	Miami	USA	High income	5.48
43	Belo Horizonte	Brazil	Upper-middle income	5.45
44	Philadelphia	USA	High income	5.36
45	St Petersburg	Russia	Upper-middle income	5.35
46	Ahmadabad	India	Lower-middle income	5.34
47	Madrid	Spain	High income	5.17
48	Toronto	Canada	High income	5.16
49	Ho Chi Minh City	Vietnam	Lower-middle income	5.1
50	Chongqing	China	Upper-middle income	5.06

Rank	Urban Area	Country	World Bank Income Group	Population in 2006 (millions)
51	Shenyang	China	Upper-middle income	4.94
52	Dallas-Fort Worth	USA	High income	4.72
53	Pune (Poona)	India	Lower-middle income	4.67
54	Khartoum	Sudan	Lower-middle income	4.63
55	Singapore	Singapore	High income	4.47
56	Atlanta	USA	High income	4.47
57	Sydney	Australia	High income	4.45
58	Barcelona	Spain	High income	4.43
59	Houston	USA	High income	4.39
60	Chittagong	Bangladesh	Low income	4.37
61	Boston	USA	High income	4.37
62	Washington DC	USA	High income	4.25
63	Hanoi	Vietnam	Lower-middle income	4.22
64	Yangon	Myanmar	Low income	4.18
65	Bandung	Indonesia	Lower-middle income	4.15
66	Detroit	USA	High income	3.99
67	Jeddah	Saudi Arabia	High income	3.96
68	Milan	Italy	High income	3.96
69	Guadalajara	Mexico	Upper-middle income	3.95
70	Surat	India	Lower-middle income	3.9
71	Guangzhou	China	Upper-middle income	3.88
72	Pôrto Alegre	Brazil	Upper-middle income	3.86
73	Casablanca	Morocco	Lower-middle income	3.83
74	Alexandria	Egypt	Lower-middle income	3.81
75	Frankfurt-Wiesbaden	Germany	High income	3.73
76	Melbourne	Australia	High income	3.71
77	Ankara	Turkey	Upper-middle income	3.69
78	Abidjan	Côte d'Ivoire	Lower-middle income	3.62
79	Recife	Brazil	Upper-middle income	3.59
80	Monterrey	Mexico	Upper-middle income	3.58
81	Montréal	Canada	High income	3.53
82	Chengdu	China	Upper-middle income	3.52
83	Phoenix-Mesa	USA	High income	3.51
84	Pusan	Republic of Korea	High income	3.49
85	Brasília	Brazil	Upper-middle income	3.48
86	Johannesburg	South Africa	Upper-middle income	3.44
87	Kabul	Afghanistan	Low Income	3.43
88	Salvador	Brazil	Upper-middle income	3.41
89	Algiers	Algeria	Upper-middle income	3.37
90	San Francisco-Oakland	USA	High income	3.36
91	Düsseldorf-Essen	Germany	High income	3.35
92	Fortaleza	Brazil	Upper-middle income	3.35
93	Medellín	Colombia	Upper-middle income	3.33
94	Berlin	Germany	High income	3.33
95	Pyongyang	Korea, Dem. Rep.	Low Income	3.33
96	Caracas	Venezuela	Upper-middle income	3.3
97	Xian	China	Upper-middle income	3.28
98	Athens	Greece	High income	3.25
99	East Rand (Ekurhuleni)	South Africa	Upper-middle income	3.23
100	Cape Town	South Africa	Upper-middle income	3.21

Source: The City Mayors Foundation, http://citymayors.com/statistics/urban_2006_1.html

ANNEX 10
Large Urban Areas Compendium Entries for Rio De Janeiro, Singapore, and Cape Town

This annex provides 3 samples of the Large Urban Areas data compendium. Please visit the following website for the complete data compendium: http://go.worldbank.org/OW7ZJN9NO0

RIO DE JANEIRO, Brazil

		Source	Year
Population (millions)	**11.62**	http://citymayors.com/statistics/urban_2006_1.html	2006
Land Area (sq. km)	**1580**	http://citymayors.com/statistics/largest-cities-area-125.html	
GDP ($ billions)	**141**	PriceWaterhouse Coopers	2008
Human Development Index (Country)	**0.72**	http://hdrstats.undp.org/en/tables/default.html	2011
Core city			
Population (millions)	6.09	http://citymayors.com/statistics/largest-cities-mayors-1.html	2011
Mayor	Eduardo Paes	http://citymayors.com/statistics/largest-cities-mayors-1.html	2011
City administrator (or equivalent)			
Characteristics of the urban area			
Population growth (average annual %)	0.97	UN Habitat, State of the World's Cities 2010-11	2010-2015
Population Density (per sq. km)	7354		
Climate Classification+	Tropical	http://koeppen-geiger.vu-wien.ac.at/	
Economy			
GDP per capita ($)	12134	PriceWaterhouse Coopers	2008
Real GDP growth rate (% per annum)	5.0	PriceWaterhouse Coopers	2008-2025
Income Distribution (Gini Index)	0.53	UN Habitat, State of the World's Cities 2010-11	2007
City unemployment rate (%)	5.5	NYC Global Partners Database	2011
Energy			
Total energy consumption per capita (GJ)			
Total energy consumption per GDP (MJ/$)			
Total electrical use per capita (kWh)	2181	Siemens Green City Index	2007
Population with authorized electrical service (%)			
Emissions and pollution			
GHG Emissions per capita (tCO2e/cap)	2.1	Cities and Climate Change: An Urgent Agenda	1998
GHG Emissions per GDP (ktCO2e/$bn)	173.0	Cities and Climate Change: An Urgent Agenda	1998
PM2.5 Concentration (mcg/cu.m)			
PM10 Concentration (mcg/cu.m)	63.7	WHO Outdoor Air Pollution Database	2009
Water, sanitation and waste management			
Total water consumption per capita (litres/day)	301.3	Siemens Green City Index	2008
Population with sustainable access to an improved water source (%)	78	IBNET	2009
Average water revenue ($/cu.m. sold)	1.28	IBNET	2009
Collection ratio (% of billed water service)	78	IBNET	2009
Population served by wastewater collection (%)	83.4	Siemens Green City Index	2007
Percentage of untreated wastewater	4	IBNET	2009
Solid waste generation per capita (kg)	525.2	Siemens Green City Index	2008
Percentage of solid waste recycled			
Population with regular solid waste collection (%)	98.6	Siemens Green City Index	2008

Climate and disaster resilience			
Multi-hazard risk (cyclones, floods, landslides)	Low	UN PREVIEW Global Risk Data Platform	
Earthquake risk	Low	UN PREVIEW Global Risk Data Platform	
Aggregate disaster vulnerability index	(to be developed)		
Environmental Protection Index (Country)	63.4	http://hdrstats.undp.org/en/tables/default.html	2011
Up-to-date Local Agenda 21 (or equivalent)?	Y/N		
Up-to-date Urban Risk Assessment?	Y/N		
Shelter			
Jobs/Housing ratio			
Population living in slums (%)	28	UN Habitat, State of the World's Cities 2010-11 (national value for urban areas)	2007
Governance			
Voter participation (% of eligible voters)			
Time to start a business (days)	68	World Bank, Doing Business Report Subnational Case Studies	2006
Debt service ratio (%)			
Transportation			
Average commute time to work (minutes)			
High capacity public transit system (km per 100,000 population)			
Light passenger transit system (km per 100,000 population)			
Number of personal automobiles per capita			
Annual number of public transit trips per capita			
Education, technology and innovation			
Education Index	0.58	London School of Economics, Cities Health and Well-Being	2011
Student/teacher ratio			
Students completing primary education (%)			
Students completing secondary education (%)			
Internet connections (per 100,000 population)			
New patents (per 100,000 per year)			
Health			
Health Index	0.58	London School of Economics, Cities Health and Well-Being	2011
Average life expectancy (years)			
Under age five mortality (per 1,000 live births)			
Prevalence of HIV (in adults aged 15 to 49, %)	0.3 – 0.6	WHO Global Health Observatory (national value)	2009
Deaths due to malaria (per 100,000 population)	0.1	WHO Global Health Observatory (national value)	2008
Prevalence of tuberculosis (per 100,000 population)	47	WHO Global Health Observatory (national value)	2010
In-patient hospital beds (per 100,000 population)			
Physicians (per 100,000 population)			

Note: Unavailable data to be provided by city or Global City Indicators Facility (GCIF), unless otherwise specified

+ Koppen Climate Classification System

SINGAPORE

		Source	Year
Population (millions)	**4.47**	http://citymayors.com/statistics/urban_2006_1.html	2006
Land Area (sq. km)	**479**	http://citymayors.com/statistics/largest-cities-area-125.html	
GDP ($ billions)	**215**	PriceWaterhouse Coopers	2008
Human Development Index	0.87	http://hdrstats.undp.org/en/tables/default.html	2011
Core city			
Population (millions)			
Mayor	Lee Hsien Loong	http://citymayors.com/statistics/largest-cities-mayors-1.html	2011
City administrator (or equivalent)			
Characteristics of the urban area			
Population growth (average annual %)	2.1	http://www.singstat.gov.sg/stats/keyind.html#demoind	2011
Population Density (per sq. km)	9332		
Climate Classification+	Tropical	http://koeppen-geiger.vu-wien.ac.at/	
Economy			
GDP per capita ($)	48098	PriceWaterhouse Coopers	2008
Real GDP growth rate (% per annum)	1.7	PriceWaterhouse Coopers	2008-25
Income Distribution (Gini Index)	0.42	UN Habitat, State of the World's Cities 2010-11	1998
City unemployment rate (%)	2	http://www.mom.gov.sg/statistics-publications/national-labour-market-information/statistics/Pages/unemployment.aspx	2011
Energy			
Total energy consumption per capita (GJ)	155.1	Siemens Green City Index	2008
Total energy consumption per GDP (MJ/$)	2.9	Siemens Green City Index	2008
Total electrical use per capita (kWh)	7949	World Development Indicators	2009
Population with authorized electrical service (%)	100	World Development Indicators	2009
Emissions and pollution			
GHG Emissions per capita (tCO_2e/cap)	7.9	Cities and Climate Change: An Urgent Agenda	1994
GHG Emissions per GDP ($ktCO_2e/\$bn$)	163.4	Cities and Climate Change: An Urgent Agenda	1994
PM2.5 Concentration (mcg/cu.m)	17.0	http://www.singstat.gov.sg/pubn/reference/yos11/statsT-climate.pdf	2010
PM10 Concentration (mcg/cu.m)	127.0	http://www.singstat.gov.sg/pubn/reference/yos11/statsT-climate.pdf	2010
Water, sanitation and waste management			
Total water consumption per capita (litres/day)	262	IBNET	2008
Population with sustainable access to an improved water source (%)	100	IBNET	2008
Average water revenue ($/cu.m. sold)			
Collection ratio (% of billed water service)			
Population served by wastewater collection (%)	100	IBNET	2008
Percentage of untreated wastewater	0	Siemens Green City Index	2009
Solid waste generation per capita (kg)	306.6	Siemens Green City Index	2009
Percentage of solid waste recycled	58	http://app.mewr.gov.sg/web/Contents/Contents.aspx?ContId=680	2010
Population with regular solid waste collection (%)	100	http://app.mewr.gov.sg/web/Contents/Contents.aspx?ContId=680	2010

Climate and disaster resilience			
Multi-hazard risk (cyclones, floods, landslides)	Low	UN PREVIEW Global Risk Data Platform	
Earthquake risk	Low	UN PREVIEW Global Risk Data Platform	
Aggregate disaster vulnerability index	(to be developed)		
Environmental Protection Index (Country)	69.6	http://hdrstats.undp.org/en/tables/default.html	2011
Up-to-date Local Agenda 21 (or equivalent)?	Y/N		
Up-to-date Urban Risk Assessment?	Y/N		
Shelter			
Jobs/Housing ratio			
Population living in slums (%)			
Governance			
Voter participation (% of eligible voters)			
Time to start a business (days)	3	World Bank Doing Business Report	2012
Debt service ratio (%)			
Transportation			
Average commute time to work (minutes)			
High capacity public transit system (km per 100,000 population)			
Light passenger transit system (km per 100,000 population)			
Number of personal automobiles per capita	0.12	http://www.lta.gov.sg/content/dam/lta/Corporate/doc/MVP01-1%20%28MVP%20by%20type%29.pdf	2011
Annual number of public transit trips per capita	438.3	http://www.lta.gov.sg/content/dam/lta/Corporate/doc/PT%20Ridership%20%282010-cy%29.pdf	2010
Education, technology and innovation			
Education Index	0.64	London School of Economics, Cities Health and Well-Being	2011
Student/teacher ratio (primary)	19.3	http://www.singstat.gov.sg/stats/themes/people/edun.html	2010
Students completing primary education (%)			
Students completing secondary education (%)	66.6	http://www.singstat.gov.sg/stats/keyind.html#demoind	2011
Internet connections (per 100,000 population)	28130	http://www.ida.gov.sg/Publications/20070822130650.aspx	2010
New patents (per 100,000 per year)			
Health			
Health Index	0.86	London School of Economics, Cities Health and Well-Being	2011
Average life expectancy (years)	81.80	http://www.singstat.gov.sg/stats/keyind.html#demoind	2011
Under age five mortality (per 1,000 live births)	2.6	World Development Indicators	2010
Prevalence of HIV (in adults aged 15 to 49, %)	0.1	WHO Global Health Observatory (national value)	2009
Deaths due to malaria (per 100,000 population)	0	WHO Global Health Observatory (national value)	2008
Prevalence of tuberculosis (per 100,000 population)	44	WHO Global Health Observatory (national value)	2010
In-patient hospital beds (per 100,000 population)	257.5	http://www.singstat.gov.sg/stats/themes/people/health.html	2010
Physicians (per 100,000 population)	180.0	http://www.singstat.gov.sg/stats/keyind.html#demoind	2011

Note: Unavailable data to be provided by city or Global City Indicators Facility (GCIF), unless otherwise specified

+ Koppen Climate Classification System

CAPE TOWN, South Africa

		Source	Year
Population (millions)	**3.21**	http://citymayors.com/statistics/urban_2006_1.html	2006
Land Area (sq. km)	**686**	http://citymayors.com/statistics/largest-cities-area-125.html	
GDP ($ billions)	**103**	PriceWaterhouse Coopers	2008
Human Development Index (Country)	**0.62**	http://hdrstats.undp.org/en/tables/default.html	2011

Core city			
Population (millions)			
Mayor	Patricia de Lille	http://citymayors.com/statistics/largest-cities-mayors-1.html	2011
City administrator (or equivalent)			
Characteristics of the urban area			
Population growth (average annual %)	0.86	UN Habitat, State of the World's Cities 2010-11	2010-2015
Population Density (per sq. km)	4679		
Climate Classification+	Temperate	http://koeppen-geiger.vu-wien.ac.at/	
Economy			
GDP per capita ($)	32087	PriceWaterhouse Coopers	2008-2025
Real GDP growth rate (% per annum)	1.8	PriceWaterhouse Coopers	2008
Income Distribution (Gini Index)	0.67	UN Habitat, State of the World's Cities 2010-11	2007
City unemployment rate (%)			
Energy			
Total energy consumption per capita (GJ)			
Total energy consumption per GDP (MJ/$)			
Total electrical use per capita (kWh)	3861	Siemens Green City Index	2007
Population with authorized electrical service (%)	89.7	Siemens Green City Index	2009
Emissions and pollution			
GHG Emissions per capita (tCO2e/cap)	7.6	Cities and Climate Change: An Urgent Agenda	2005
GHG Emissions per GDP (ktCO2e/$bn)	236.9	Cities and Climate Change: An Urgent Agenda	2005
PM2.5 Concentration (mcg/cu.m)			
PM10 Concentration (mcg/cu.m)			
Water, sanitation and waste management			
Total water consumption per capita (litres/day)	225.2	Siemens Green City Index	2009
Population with sustainable access to an improved water source (%)	91.4	Siemens Green City Index	2009
Average water revenue ($/cu.m. sold)	0.57	IBNET	2006
Collection ratio (% of billed water service)	83	IBNET	2006
Population served by wastewater collection (%)	94.1	Siemens Green City Index	2009
Percentage of untreated wastewater	6	IBNET	2006
Solid waste generation per capita (kg)	572.9	Siemens Green City Index	2010
Percentage of solid waste recycled			
Population with regular solid waste collection (%)			

Climate and disaster resilience			
Multi-hazard risk (cyclones, floods, landslides)	Medium	UN PREVIEW Global Risk Data Platform	
Earthquake risk	Low	UN PREVIEW Global Risk Data Platform	
Aggregate disaster vulnerability index	(to be developed)		
Environmental Protection Index (Country)	50.8	http://hdrstats.undp.org/en/tables/default.html	2011
Up-to-date Local Agenda 21 (or equivalent)?	Y/N		
Up-to-date Urban Risk Assessment?	Y/N		
Shelter			
Jobs/Housing ratio			
Population living in slums (%)	28.7	UN Habitat, State of the World's Cities 2010-11 (national value for urban areas)	2007
Governance			
Voter participation (% of eligible voters)			
Time to start a business (days)	19	World Bank, Doing Business Report (national)	2012
Debt service ratio (%)			
Transportation			
Average commute time to work (minutes)			
High capacity public transit system (km per 100,000 population)			
Light passenger transit system (km per 100,000 population)			
Number of personal automobiles per capita			
Annual number of public transit trips per capita			
Education, technology and innovation			
Education Index	0.61	London School of Economics, Cities Health and Well-Being	2011
Student/teacher ratio			
Students completing primary education (%)			
Students completing secondary education (%)			
Internet connections (per 100,000 population)			
New patents (per 100,000 per year)			
Health			
Health Index	0.31	London School of Economics, Cities Health and Well-Being	2011
Average life expectancy (years)			
Under age five mortality (per 1,000 live births)			
Prevalence of HIV (in adults aged 15 to 49, %)	17.8	WHO Global Health Observatory (national value)	2009
Deaths due to malaria (per 100,000 population)	0.2	WHO Global Health Observatory (national value)	2008
Prevalence of tuberculosis (per 100,000 population)	795	WHO Global Health Observatory (national value)	2010
In-patient hospital beds (per 100,000 population)			
Physicians (per 100,000 population)			

Note: Unavailable data to be provided by city or Global City Indicators Facility (GCIF), unless otherwise specified

+ Koppen Climate Classification System

ANNEX 11

Estimated Multi-Hazard Risk Index for the 100 Largest Urban Areas

This dataset includes an estimate of the risk induced by multiple hazards (tropical cyclone, flood, and landslide induced by precipitation). The unit is the estimated risk index from 1 (low) to 5 (extreme). This product was designed by UNEP/GRID-Europe for the Global Assessment Report on Disaster Risk Reduction (GAR).

City	Country	Population (Millions)	Risk Index
Mexico City	Mexico	19.24	Low
Mumbai (Bombay)	India	18.84	Low
Jakarta	Indonesia	13.67	Low
Buenos Aires	Argentina	13.52	Low
Karachi	Pakistan	12.20	Low
Rio de Janeiro	Brazil	11.62	Low
Cairo	Egypt	11.29	Low
Beijing	China	10.85	Low
Istanbul	Turkey	10.00	Low
Tehran	Iran	7.42	Low
Bangalore	India	6.75	Low
Dortmund, Bochum	Germany	6.57	Low
Riyadh	Saudi Arabia	5.76	Low
Belo Horizonte	Brazil	5.45	Low
St Petersburg	Russia	5.35	Low
Singapore	Singapore	4.47	Low
Sydney	Australia	4.45	Low
Barcelona	Spain	4.43	Low
Jidda	Saudi Arabia	3.96	Low
Milan	Italy	3.96	Low
Alexandria	Egypt	3.81	Low
Frankfurt, Wiesbaden	Germany	3.73	Low
Chengdu	China	3.52	Low
Phoenix, Mesa	USA	3.51	Low
Brasília	Brazil	3.48	Low
Johannesburg	South Africa	3.44	Low
Salvador	Brazil	3.41	Low
Algiers	Algeria	3.37	Low
Fortaleza	Brazil	3.35	Low
Berlin	Germany	3.33	Low
Athens	Greece	3.25	Low
East Rand (Ekurhuleni)	South Africa	3.23	Low
Hyderabad	India	6.34	Moderate
Düsseldorf, Essen	Germany	3.35	Moderate
São Paulo	Brazil	18.61	Moderate
Washington, DC	USA	4.25	Moderate
Caracas	Venezuela	3.30	Moderate
Ahmadabad	India	5.34	Moderate
Porto Alegre	Brazil	3.86	Moderate
Dallas, Fort Worth	USA	4.72	Moderate
London	UK	7.61	Moderate
Abidjan	CÐte d’Ivoire	3.62	Moderate
Atlanta	USA	4.47	Moderate
Osaka, Kobe	Japan	11.32	Moderate

City	Country	Population (Millions)	Risk Index
Shenyang	China	4.94	Medium
Guadalajara	Mexico	3.95	Medium
Detroit	USA	3.99	Medium
Madrid	Spain	5.17	Medium
Seoul	South Korea	9.52	Medium
Medellín	Colombia	3.33	Medium
Toronto	Canada	5.16	Medium
Miami	USA	5.48	Medium
Philadelphia	USA	5.36	Medium
Xian	China	3.28	Medium
Boston	USA	4.37	Medium
Santiago	Chile	5.70	Medium
Cape Town	South Africa	3.21	Medium
Melbourne	Australia	3.71	Medium
Chongqing	China	5.06	Medium
Montreal	Canada	3.53	Medium
Bandung	Indonesia	4.15	Medium
Los Angeles	USA	12.22	Medium
New York	USA	18.65	Medium
San Francisco, Oakland	USA	3.36	High
Chicago	USA	8.80	High
Casablanca	Morocco	3.83	High
Monterrey	Mexico	3.58	High
Guangzhou	China	3.88	High
Tokyo	Japan	35.53	High
Moscow	Russia	10.82	High
Recife	Brazil	3.59	High
Kabul	Afghanistan	3.43	High
Lagos	Nigeria	11.70	High
Ankara	Turkey	3.69	High
Ho Chi Minh City	Vietnam	5.10	High
Lima	Peru	8.35	High
Paris	France	9.89	High
Houston	USA	4.39	Extreme
Bangkok	Thailand	6.65	Extreme
Bogotá	Colombia	7.80	Extreme
Tianjin	China	9.39	Extreme
Hong Kong	China	7.28	Extreme
Lahore	Pakistan	6.57	Extreme
Baghdad	Iraq	6.06	Extreme
Calcutta	India	14.57	Extreme
Pune (Poona)	India	4.67	Extreme
Pusan	Republic of Korea	3.49	Extreme
Yangon	Myanmar	4.18	Extreme
Khartoum	Sudan	4.63	Extreme
Chennai (Madras)	India	7.04	Extreme
Shanghai	China	12.63	Extreme
Hanoi	Vietnam	4.22	Extreme
Pyongyang	North Korea	3.33	Extreme
Delhi	India	16.00	Extreme
Surat	India	3.90	Extreme
Kinshasa	Congo	5.89	Extreme
Chittagong	Bangladesh	4.37	Extreme
Metro Manila	Philippines	10.80	Extreme
Wuhan	China	6.18	Extreme
Dhaka	Bangladesh	13.09	Extreme

Source: UNEP/GRID-Europe, http://preview.grid.unep.ch

ANNEX 12
Urban Risk Assessment Review

No.	Title/ Organization	Year	Methodology	Scope/Regions Covered	City rankings	Comments
			STUDIES			
1	OECD, Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes	2008	Evaluated 136 port cities of over 1 million population with exposure to 1-in-100-year, surge-induced flood events. The study looks at the exposure of population and assets in 2005 and those predicted in 2070 for different climate change scenarios. Future predictions account for population growth, urbanization, ground subsidence, and climatic changes.	Port cities of over 1 million population globally	Dhaka Chittagong Ningbo Lagos Khulna Kolkata Lomé Abidjan Haiphong Krung Thep (Bangkok) Surat Ho Chi Minh City Chennai Palembang Jakarta Mumbai Fuzhou Fujian Tianjin Xiamen	City rankings developed on 2005 population exposure and asset exposure, as well as 2070 population and asset exposure Disaster risk other than 100-year, surge-induced flood events are not assessed.
2	Munich Re, *Megacities Megarisks*	2004	The index is composed of three variables: exposure to hazards, vulnerability of the built environment, and value of exposed property. Vulnerability is based on an estimation of the vulnerability of the predominant form of residential construction to hazards, the standard of preparedness, and safeguards including building regulations, urban planning for specific hazards, and flood protection, as well as building density. The values of exposed property are estimated using the average values per household and the GDP for commerce and industry.	Munich Re Group's NatCat database was used to prepare a natural hazard risk index for 50 of the world's largest (over 2 million population) and most economically important cities (based on city GDP as a percentage of a country's GDP). The index analyzed 30 large cities in low- and middle-income nations and 20 large cities in high-income nations.	Tokyo Los Angeles Osaka, Kobe, Kyoto New York Manila, Quezon London Paris Chicago Mexico City Washington, Baltimore Seoul, Incheon Beijing Ruhr area Shanghai Moscow Bogotá Dhaka Mumbai Istanbul Teheran Calcutta Buenos Aires Lima Jakarta Karachi São Paulo Rio de Janeiro Cairo Delhi Lagos	The index is most heavily influenced by the exposure to asset values, followed by hazard. Vulnerability plays a lesser role.
3	GFDRR, Henrike Brecht, and WBG (2007) GFDRR, *Natural Hazards, Unnatural Disasters* (2010)	2010	Exposure to cyclones and earthquakes in large cities may rise from 680 million people in 2000 to 1.5 billion people by 2050 City-specific population projections to 2050 for this report are combined with geographic patterns of hazard events representative of the 1975–2007 period.	Globally	Highest hazard exposure growth in cities of the following regions (in order): South Asia (cyclones) Sub-Saharan Africa East Asia (earthquakes) Latin America (earthquakes)	Current city rankings are based on 2005 hot-spot study. The forthcoming study will include analysis on revised data.

No.	Title/ Organization	Year	Methodology	Scope/Regions Covered	City rankings	Comments
			CITY RISK INDICES			
4	WWF, *Climate vulnerability Scorecard* http://assets.panda.org/downloads/mega_cities_report.pdf	2009	Combined scores were used to rank cities. Individual score given to the following: 1. **Exposure:** to temperature change, precipitation change, sea level rise, extreme weather event 2. **Socioeconomic sensitivity:** population, wealth (per capita GDP), contribution to national GDP 3. **Adaptive capacity:** existing preparedness/response	Compared 11 selected coastal cities of Asia	Dhaka Jakarta Manila Kolkata Phnom Penh Ho Chi Minh Shanghai Bangkok Hong Kong Kuala Lumpur Singapore	
5	UNDP, *Disaster Risk Index* http://www.undp.org/cpr/disred/documents/publications/rdr/english/c2/a.pdf	2004	The DRI enables the calculation of the average risk of death per country in large- and medium-scale disasters associated with earthquakes, tropical cyclones, and floods, based on data from 1980 to 2000.		For countries, not available at urban level	Index based on historical trends (1980–2000) and other socio-economic indicators collected from global datasets. The assessment does not include: (a) small scale disasters, (b) drought and climate change risk, (b) Indicators (or current progress) for disaster risk management.
6	Stanford University, Earthquake Disaster Risk Index http://www.stanford.edu/group/blume/pdffiles/Tech%20Reports/TR121_Davidson.pdf	1997	Developed earthquake risk index and applied to selected cities. Index includes indicators on: **Hazard:** ground shaking, collateral hazards **Exposure:** population, infrastructure, economy **Vulnerability:** population and infrastructure **External context:** political and economic **Emergency response and recovery planning:** planning, resources, mobility, and access	Selected cities from all parts of the world based on past exposure to earthquake	Tokyo Lima Manila Jakarta Boston Istanbul Mexico City San Francisco San Tiago St. Louis	
7	IADB, Risk Index at urban level http://enet.iadb.org/idbdocswebservices/idbdocsInternet/IADBPublicDoc.aspx?docnum=465922	2010	Not operationalized at sub-national level, but methodology exists	Not operationalized at sub-national level, but methodology exists		
8	IADB, *Indicators of Disaster Risk and Risk Management* http://idbdocs.iadb.org/wsdocs/getdocument.aspx	2010	The Disaster Deficit, Local Disaster, and Prevalent Vulnerability indices (DDI, LDI and PVI) are risk proxies that measure different factors that affect overall risk at the national level. IADB gas also developed the Risk Management Index, the first systematic and consistent international technique developed to measure risk management performance.	Available for Latin American countries		
9	ECA Climate Vulnerability Index http://www.worldbank.org/eca/climate/ECA_CCA_Full_Report.pdf	2008	The index combines three sub-indices capturing a country's exposure, sensitivity, and adaptive capacity. The first, exposure, is based on an index measuring the strength of future climate change relative to today's natural variability (Baettig et al. 2007). The index is available on a country basis and includes both annual and seasonal temperature and precipitation indicators. It combines the number of additional hot, dry, and wet years; hot, dry, and wet summers; and hot, dry, and wet winters, projected over the 2070–2100 period relative to the 1961–1990 period. This suggests that the countries most exposed to future climatic change are Russia, Albania, Turkey, Armenia, and, to a lesser extent, Macedonia and Tajikistan.	For ECA countries		
			MAPS OF NATURAL HAZARDS AND CLIMATE CHANGE TREND, ONLINE SOFTWARE AND DATABASE			
10	Columbia University and World Bank, Global Hot Spot study http://www.ldeo.columbia.edu/chrr/research/hotspots/maps.html	2005	Presents global risks of two disaster-related outcomes: mortality and economic losses. Estimated risk levels by combining hazard exposure with historical vulnerability for two indicators of elements at risk—gridded population and GDP per unit area—for six major natural hazards: earthquakes, volcanoes, landslides, floods, drought, and cyclones. Three indicators were used: 1. Disaster-related mortality risks, assessed for global gridded population 2. Risks of total economic losses, assessed for global gridded GDP per unit area 3. Risks of economic losses expressed as a proportion of the GDP per unit area for each grid cell	Available at country level		Global maps are available for various types of disaster risks

No.	Title/ Organization	Year	Methodology	Scope/Regions Covered	City rankings	Comments
11	UNDP GRIP http://www.gripweb.org		In process of developing an online interactive map application for urban disaster risk			
12	*Global Assessment Report on Disaster Risk Reduction* http://www.preventionweb.net/english/hyogo/gar/report/index.php?id=9413&pid:34&pil:1 http://www.preventionweb.net/english/maps/	2009	The PREVIEW Global Risk Data Platform is a multiple-agency effort to share spatial data information on global risk from natural hazards. Users can visualize, download, or extract data on past hazardous events, human and economic hazard exposure, and risk from natural hazards. It covers tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis, and volcanic eruptions. The collection of data is made via a wide range of partners. This was developed as a support to the Global Assessment Report on Disaster Risk Reduction (GAR) and replaces the previous PREVIEW platform available since 2000. Many improvements were made on the data and on the application.			
13	Reducing Disaster Risk: *A Challenge for Development* http://www.undp.org/cpr/disred/rdr.htm	2004	Includes Disaster Risk Index for countries			
14	Munich Re Map of Natural Hazards	Every year	Global map showing disaster and climate change (related hazard) risks Primarily assesses risk to assets	Global maps		
15	DesInventar http://www.desinventar.org		DesInventar is a conceptual and methodological tool for the construction of databases of loss, damage, or effects caused by emergencies or disasters. The Network of Social Studies in the Prevention of Disasters in Latin America (Red de Estudios Sociales en Prevención de Desastres en América Latina - LA RED) conceptualized a system of acquisition, consultation, and display of information about disasters of small, medium, and greater impact, based on pre-existing data, newspaper sources, and institutional reports in nine countries in Latin America. The developed conceptualization, methodology, and software tool is called the Disaster Inventory System, or DesInventar (Sistema de Inventario de Desastres, DesInventar). It includes: Methodology (definitions and help in the management of data) Database with flexible structure Software for input into the database Software for consultation of data (not limited to a predefined number of consultations). with selection options for search criteria.	Online platform and dataset for Latin America and parts of Asia and Africa		Online software for disaster risk assessment
16	FEMA (United States Federal Emergency Management Agency), HAZUS http://www.fema.gov/plan/prevent/hazus/index.shtm		HAZUS-MH is a powerful risk-assessment methodology for analyzing potential losses from floods, hurricane winds, and earthquakes. In HAZUS-MH, current scientific and engineering knowledge is coupled with the latest GIS technology to produce estimates of hazard-related damage before, or after, a disaster occurs. Potential loss estimates analyzed in HAZUS-MH include: **Physical damage** to residential and commercial buildings, schools, critical facilities, and infrastructure; **economic loss**, including lost jobs, business interruptions, repair and reconstruction costs; and **social impacts**, including estimates of shelter requirements, displaced households, and population exposed to scenario floods, earthquakes and hurricanes.	Only for USA		Online software for disaster risk assessment
17	Tyndall Centre, Disaster Risk Index		The UK-based Tyndall Centre for Climate Change Research uses data relating to natural disasters for the assessment of recent historical and current risk associated with climatic variability. Current risk associated with extreme climate events is used as a proxy for risk associated with climate change in the future. The data used is derived from EM-DAT with population data from the World Bank.	At country level		

ANNEX 13
Summary of "The Next Frontier of E-Government*

In 1950, one-third of the world population lived in cities. Half a century later, the proportion had increased to one-half, and it is estimated that by 2050, 6 billion people (that is, two-thirds of the world population) will live in cities. Currently the urban population of developing countries is projected to double in 30 years, increasing from 2 billion in 2000 to 4 billion in 2030. In less than 10 years, most of the "megacities" emerging from that process will be located in developing countries (see Figure 1).

Such projections obviously raise questions about the ability of the cities of the future to sustain this type of growth while maintaining adequate levels of production and delivery of key public services such as water, transport, electricity, sanitation, education, and containment of crime and pollution. There is, however, another side to this equation, often overlooked. It relates to the emerging role of cities (and of subnational entities generally) to become global players—as attractors of foreign investment, competitiveness hubs, and/or platforms for the combination of local and international components of global production and supply chains.

At the same time, more and more governments around the world are seizing opportunities to move to "e-government" as a way of enhancing the effectiveness and efficiency of their national public sectors, in particular through outsourcing the production and delivery of public services to the private sector. This trend compounds another one, by which central governments have been delegating an increasing number of their traditional responsibilities to subnational entities such as states, regions, municipalities, or cities. Many phrases and philosophies have been coined and formulated

FIG. 1
Projected Population Size of Mega-cities in 2015

Source: UN Habitat and authors' calculations.

*This article is a summary of a previously published chapter, for the full list of references, please see the original published article (Lanvin and Lewin 2006).

to describe or justify such a process, including *new federalism* in the United States, *de-centralization* and *de-concentration* in many European countries, and even *subsidiarity* in the EU.

We are hence witnessing the rapid convergence and combination of three trends: (a) the growth in size and economic weight of local entities such as cities; (b) the increasing ability and will of governments to use information technologies and outsourcing to fulfill their tasks and serve their citizens better through e-government; and (c) the growing potential (and obligation) of local entities (typically cities) to act as global players, designing and implementing their own policies and strategies to attract investment and carving out their share of benefits from the emerging global economy.

The Emergence of 'Local Global Players'

Both economic and urban literatures have long identified cities as key players in global competition, and even as central engines in shaping and spreading globalization itself. Phrases such as *global cities*[1], *world cities*[2], or *networked cities*[3] have been coined in the process. A growing number of local governments are emerging as "local global players" (LGPs), competing for international markets and investments. Regularly, international magazines publish rankings of cities worldwide, according to cost of living and quality of life. Sometimes called *e-cities*, *Internet cities*, or *knowledge cities*, new "e-ready" hubs seem to spring up around the world.

Successful LGPs (such as Singapore, for example, or Andhra Pradesh in India), have combined superior levels of connectivity, a capable pool of human resources, and an innovative private sector. All of these can be furthered by local government policy; however, the quality and efficiency of local efforts and governance that are key determinants of the success and the competitiveness of "local global hubs" are less often noticed or quantified. Local e-government is emerging today as a powerful tool by which such LGPs have enhanced and will continue to enhance their own competitiveness and that of their respective countries.

In many parts of the world, building and promoting local champions of e-readiness is perceived as a national priority by central governments. In countries as diverse as Tunisia, Morocco, Senegal, Russia, the United Arab Emirates, Mexico, Qatar, or Saudi Arabia, major plans are being designed and launched to build local versions of IT parks, business process off-shoring (BPO) centers, and Internet/knowledge cities in an effort to capture part of the increased foreign direct investment, employment, and economic growth that deepening globalization is expected to bring.

It is increasingly recognized that it is not only a national government-led policy decision to support a certain industry such as ICT over others—as in the case of a localized IT park or a municipal decision to implement a city strategy for global excellence. It is not only a top-down or supply-driven approach that is causing local performance to gain relevance, yet relatively little attention has been given so far to analyzing on a globally comparative basis the role of e-government services in successful LGPs.

How Do ICT and E-Government Benefit Local Global Players?

Apart from typical national e-government services such as registrations, customs, taxation, and elections, it is local governments that have direct contact with citizens for a multitude of services; these local governments also attend to a large number of citizens' needs. Specific e-government

[1] See Marcuse and Van Kempen (1999).
[2] See Sassen (1995) and Knox (2002).
[3] See Townsend (2001).

services are increasingly handled at the local rather than national level. This is the case, for instance, for small- and medium-sized enterprise (SME) registration, vehicle and drivers' licenses, enrollment at educational institutions and vocational programs, furthering human resources skills, or professional authorizations and licenses (for example, for shops, pharmacies, and so on). The provision of increasing local e-government services contributes to e-readiness and competitiveness at the global level.

A Tale of Many Cities

Although analytical efforts have been made to describe local e-government initiatives and their good practices, remarkably little attention has been granted to measuring the e-readiness of subnational spaces, including cities. Two of the more useful attempts to measure "urban performance" or competitiveness are by Kaufmann et al. at the World Bank and by Rutgers University in collaboration with South Korea's Sungkyunkwan University in Seoul. Kaufmann et al. include indicators that are vital to determining a city's level of e-readiness, such as access to electricity, telephone lines, mobile telephones, and Internet in schools.[4] In contrast, the Rutgers-SKKU e-Governance Performance Index 2005 aims at ranking cities in terms of e-government performance, leaving out some indicators of e-readiness such as access to ICT and the enabling environment. Combined with the World Economic Forum/INSEAD's *Global Information Technology Report*'s Networked Readiness Index (NRI) 2006, in which one can find a significant number of key indicators that are relevant to the local level—for example, regulatory environment, intensity of local competition, firm-level technology absorption, and protection of property rights, these three sets of data shed preliminary light onto the local e-government trends.

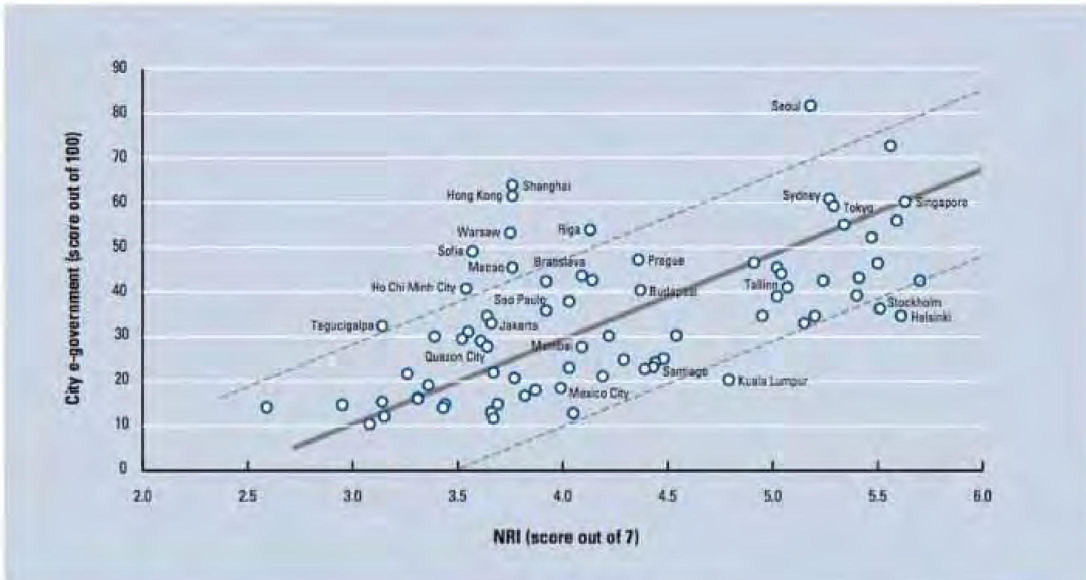
By comparing the overall city e-governance score of the Rutgers-SKKU dataset with the overall country networked readiness score of the NRI, one finds that the link between e-government performance of individual cities and the e-readiness of their respective countries is not straightforward (see Figure 2a).

In Figure 2a, the overall trend demonstrates that the majority of countries exhibit a degree of local e-government performance (the Rutgers-SKKU e-Governance Performance Index on the vertical axis) in line with what one could expect from their national networked readiness score (the NRI on the horizontal axis). However, several cities seem to be performing less successfully at the local level than their overall networked readiness would indicate (for example, Kuala Lumpur, Stockholm, and Helsinki). Others, on the contrary, perform better as local e-government hubs than the network-readiness of their respective countries would suggest. This is the case for Tegucicalpa (Honduras), Ho-Chi-Minh City (Vietnam), Warsaw (Poland), Macao, Hong Kong, Shanghai (China), Sofia (Bulgaria), and Riga (Latvia). In particular, three Eastern European cities in developing countries—Sofia, Warsaw, and Riga—are scoring close to or above 50 on the city axis; they are joined by three additional Eastern European cities—Tallinn, Bratislava, and Budapest—once the bar is lowered to scores or 40 or higher. Clearly there is a story to be told on city-level successes in Eastern European local e-government.

Indeed, the picture becomes more interesting and somewhat different when one considers regional subsamples of the same data. Because the overall sample—which is based on the common subset of

[4]See Kaufmann et al. (2006).

FIG. 2A
City e-Government vs. Overall Networked Readiness: World



Source: NRI 2006-07; Rutgers-SKKU e-Governance Performance Index 2005; and authors' calculations.

NRI and the Rutgers- SKKU e-Governance Performance Index, making a total of 76 countries—is small, such a disaggregation cannot be pushed too far. Taking it to the level of broad regions (North America, South America and the Caribbean, Western Europe, Eastern and Central Europe, Africa, the Middle East, and Asia and the Pacific), a few interesting observations emerge.

For Asia and the Pacific, we find an ellipse that is flat (see Figure 2b), indicating a stronger correlation between overall network-readiness and municipal e-government performance. However, there are notable exceptions. Shanghai and Hong Kong as cities rank higher (Shanghai at 63.93 and Hong Kong at 61.51) than the NRI score of China as a whole (3.68) would suggest. The same is true for Seoul, the undisputed champion of the Rutgers-SKKU index with a score of 81.70; while Korea scores "only" 5.14 in this year's NRI. The opposite story seems to affect Kuala Lumpur, which—as a city—performs more poorly than Malaysia as a country. At roughly the same level of overall network-readiness, the cities of Quezon City (Philippines), Jakarta (Indonesia), Ho Chi Minh City (Vietnam), and Macao, Hong Kong, and Shanghai (China)[5] show stark differences in local e-government performance. To some extent, the same can be said about Tokyo and Sydney, which rank closely on both measures, but when compared with similarly nationally networked Seoul, they differ with a markedly lower local e-government score.

Moving to South America, a richer set of data offers interesting insights about the relation between city and country performance. Figure 2c shows that the dispersion of South American countries along the spectrum of network readiness is broader than that of the corresponding countries along the axis of city e-government performance—trans-

[5]It must be noted here that, for the purposes of this chapter, Hong Kong, Shanghai, and Macao have been treated in the same manner: e-governance indicators (Rutgers-SKKU data) have been mapped against the country NRI rating for China. This choice was made both for consistency reasons (treating all Chinese cities in the same fashion), but also because it befits the overall purpose of this section, which is to identify cities for which local e-governance performance is above (or below) what the NRI performance of their respective national environments would suggest.

lating visually in a rather flat ellipse covering the cloud of points. Tegucicalpa (Honduras) and Sao Paolo (Brazil) clearly outperform their respective countries, while Santiago (Chile) seems to tell the opposite story. The difference is striking between the respective city-level e-government performances of cities such as regional high-performer Sao Paolo on one hand and Mexico City on the other, although both cities operate with very similar levels of overall networked readiness.

As might be expected, Europe offers a slightly complex picture, even if one separates Western Europe from Eastern and Central Europe (Figure

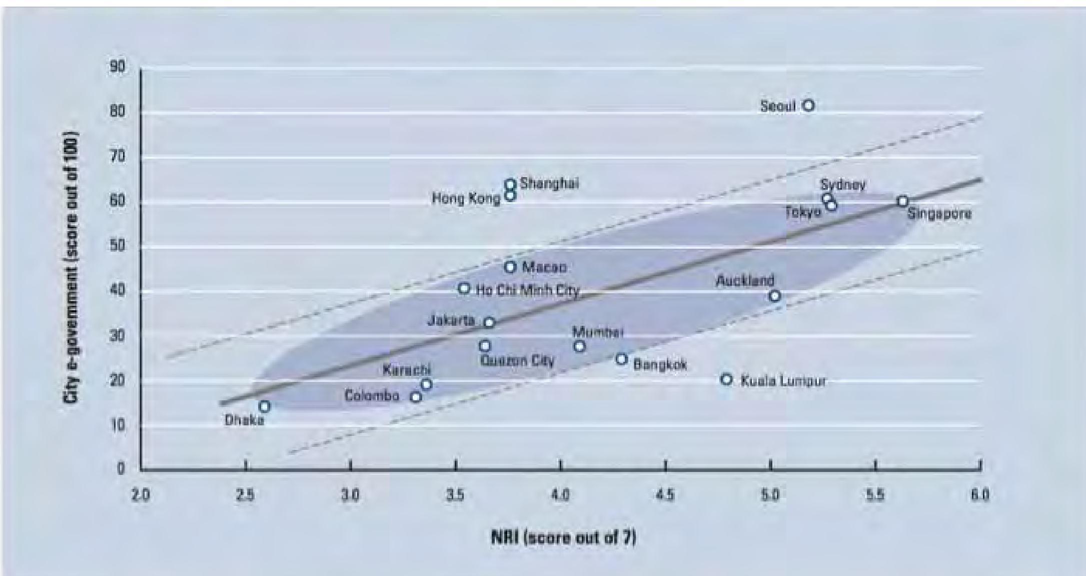


FIG. 2B
City e-Government vs. Overall Networked Readiness: Asia and the Pacific

Source: NRI 2006-07; Rutgers-SKKU e-Governance Performance Index 2005; and authors' calculations.

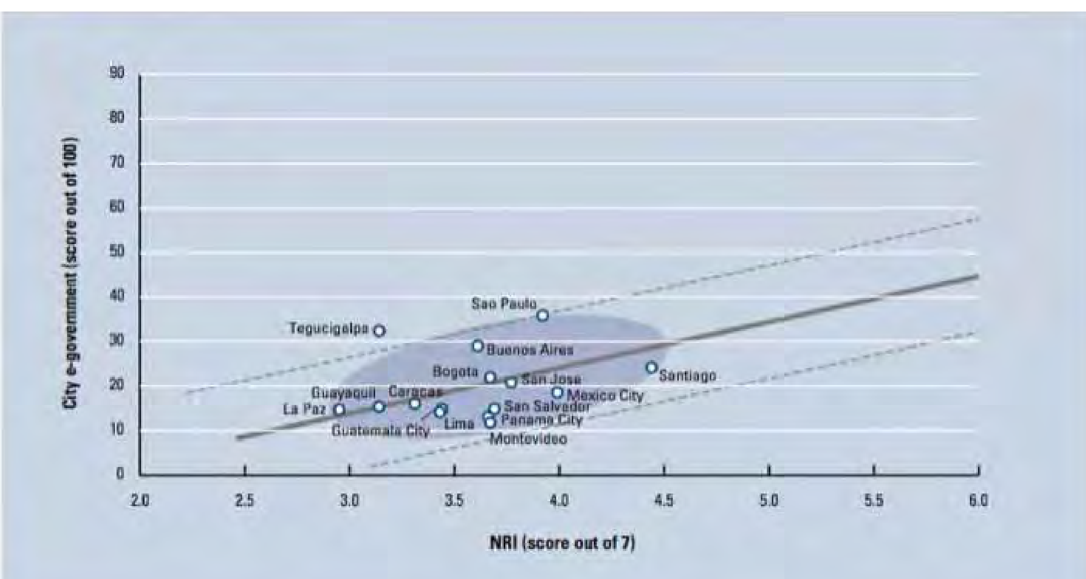
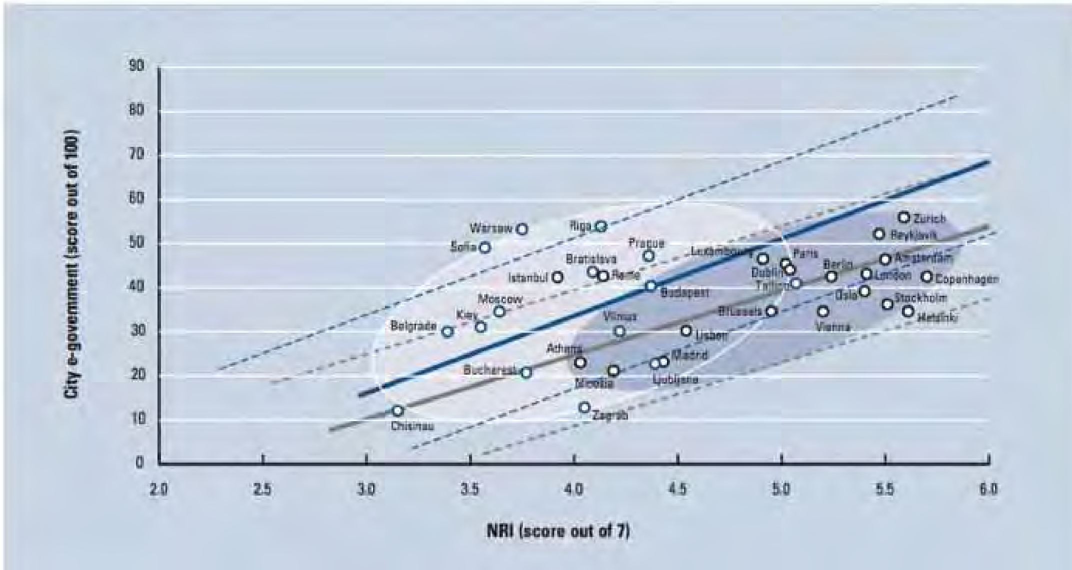


FIG. 2C
City e-Government vs. Overall Networked Readiness: South America

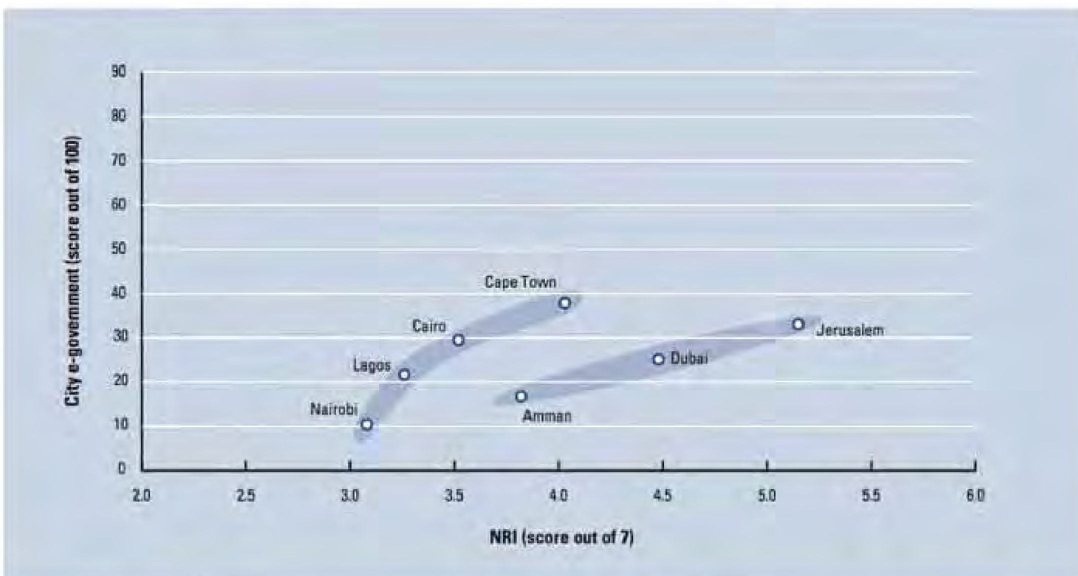
Source: NRI 2006-07; Rutgers-SKKU e-Governance Performance Index 2005; and authors' calculations.

FIG. 2D
City e-Government vs. Overall Networked Readiness: Eastern and Western Europe



Source: NRI 2006-07; Rutgers-SKKU e-Governance Performance Index 2005; and authors' calculations.

FIG. 2DE
City e-Government vs. Overall Networked Readiness: Africa, Middle East, and North America



Source: NRI 2006-07; Rutgers-SKKU e-Governance Performance Index 2005; and authors' calculations.

2d). A first conclusion is that the difference between "old Europe" and "new Europe" is much less visible from the point of view of cities' performance than it is from that of overall network readiness. At the national level, Estonia, the birthplace of Skype, remains the network readiness champion among emerging European economies, but most of the other Eastern European economies considered also compare well with the laggards of Western Europe (for example, the Czech Republic, Hungary, Lithuania, Slovenia compare favorably with Cyprus, Greece, and Italy). However, on the city scale, Eastern Europe has a number of superior performers, including Bratislava (Slovakia), Prague (Czech Republic), Sofia (Bulgaria), and, above all, Warsaw (Poland) and Riga (Latvia), who are leaders in the European region as a whole.

The e-government performance of those last three cities is clearly higher than their respective overall networked readiness levels would indicate. The city-level dataset offers further insight into the leadership of Warsaw, Prague, Riga, and Tallinn with regard to its subindices on usability, content, and service delivery. Notably, no Eastern European city scored well in the privacy and security subindex; however, they performed well (often being in the top 10) in the other categories (usability, content, and service delivery).

Finally, the dataset used in this study offers only a small set of cities for three regions (two cities in North America, three in the Middle East, and four in Africa—if one includes Cairo in Africa rather than in the Middle East)—a sample that is not sufficiently large to make significant observations. One can notice, however, that in those three regions the correlation between the NRI and the Rutgers-SKKU index is strong (see Figure 2e).

The Next Frontier: Local E-Readiness

The analysis above has led to three major conclusions:

- Subnational economic spaces (cities in particular) have played a central role in shaping the current wave of globalization. The emergence of LGPs can be seen as a revenge of geography, whereby the benefits of the "death of distance" (which have allowed international operators to invest, produce, and sell across global networks of cooperation) have been combined with those of the physical proximity or congregation of local players (for example, ICT hubs in India, or more complex combinations of talents such as in London's City).

- The dynamics of the ICT sector, and of ICT infrastructure and services in general, tend to reinforce the influence and roles of the local level in the overall process of globalization. The advent of short-range telecommunications technologies such as WiFi or WiMAX, combined with the regulatory space offered to broadband providers generally, are allowing the emergence of new business models that provide information-intensive services (including e-government) at the local level. In countries where most of the steps have been taken to establish e-government at the national level (as is the case in many Latin American countries, for instance), possibilities for taking advantage of new advances in IT seem to be even more significant at the local (and particularly municipal) level. For the next few years, and for all those reasons, the local level can truly be seen as the next frontier of e-government on a worldwide scale.

- The various regions of the world tell different stories about the respective abilities of national economies and cities to enhance their respective levels of network readiness, and to use e-government as a tool for competitiveness, good governance, and improvement of the quality of life of their citizens. However, they all show (even if at varying degrees) that the digital divide is less broad between cities than it is between countries. This results not only from the superior agility of smaller economic spaces to seize opportunities in rapidly changing environments, but also from the fact that LGPs tend to network almost naturally with each other—the result of common technical constraints (for example, international ports need to adopt common procedures and technical norms to accommodate certain types of vessels, or deal with multi-modal transport), or of the emergence of standard practices in the ways in which global business is being carried out across national borders. In all regions, some world cities emerge from the pack, showing higher rates of e-readiness (and e-government readiness) than their respective countries.

ANNEX 14
Piloting in Sustainable Cities

Building sustainable cities will require a transformation, over the coming four decades, as significant as the Industrial Revolution. This transformation will occur at the intersection of clean energy and ICT (Rifkin 2011). The Climate Group is calling it the Clean Revolution—a massive scale-up of technologies, solutions, business models, and governance to put the world on a path toward a low-carbon, sustainable future. We will need to provide for 7 billion (or more) people who will be living in cities in 2050, with an additional 3 billion entering the middle class. And we must do all this at just one-tenth of the greenhouse gas emissions we produce today (Climate Group 2009).

It is in cities that governance is needed to make this transition possible, along with supporting political action at sub-national and national levels. Cities and local authorities are hubs for innovation. Cities are also prime sites for doing more with less and finding the benefits from increased concentration of people, while avoiding negative externalities such as congestion, loss of amenities, higher prices for key services such as electricity, and peak energy demand.

How Do Cities Make the Clean Revolution a Reality?

The early stages of the Clean Revolution are already underway, characterized by pilot projects that test new solutions to a city's challenges, involve the private sector, and test new ways to influence behavior, before the city makes large investments in new infrastructure, technologies, or services. Pilots are taking place around the world in response to climate change and sustainability challenges. Case studies appear on websites and in technical papers in academic journals.

Pilots, or small-scale rollouts of solutions that are phased to scale over time, help city leaders and the private sector build confidence in new ways of meeting citizens' needs. If the city has made long-term goals very clear, pilots arise independently either from the private sector or other actors. In other cases, they arise directly from investment by the city or national government, which may set up special funds for pilot projects. The European Commission regularly funds sustainable city solutions as part of Framework Programme (FP7) research funding.[6] Stimulus packages around the world in the last four years have supported "green growth" solutions. Singapore is investing $1 billion in clean energy-related projects in order to attract talent and solutions to Singapore. The World Bank and other multilateral institutions fund climate change-related mitigation actions, many of which occur in cities.

Two key criteria for successful sustainable cities are (a) the involvement of private actors such as NGOs and businesses, and (b) support for individual behavior change—for instance, through the provision of information on cost- and energy-saving measures. Private actors may provide funding, independently or through public-private partnerships; they may provide new and innovative technologies, specially developed or adapted from what is done elsewhere; they can provide information and knowledge, and help disseminate it to citizens.

The main areas of city consumption that lead to unsustainable use of resources are electricity (lighting, appliances, electronic devices), building heating and cooling, transportation, and industry. In each of these areas, it is possible to replace a high-carbon technology with a lower-carbon version, or provide alternative activities that result in lower-carbon emissions.

[6] http://cordis.europa.eu/fp7/home_en.html

City pilot projects may therefore be broadly differentiated into two areas:

1. ***Replacing an existing technology with a better, more sustainable version of that technology.*** A classic example is incandescent lighting, which can be replaced by much more efficient forms of lighting such as LEDs.

2. ***Trying a new service or modification to the existing service.*** In tackling transportation congestion challenges, a policy maker has the choice to encourage vehicles themselves to be more efficient (such as with CAFE standards[7]), encourage reductions in the use of the same number of vehicles, or remove the vehicles from the roads altogether. The first approach necessitates that some of the vehicles provided by the private sector are more efficient than those currently on the road (like the LED example above), and that more of these efficient vehicles can be rapidly rolled out, replacing existing vehicles. This technological approach is the focus in much of the piloting work that private companies undertake in the laboratory and in the market. The other two options for reducing the impact of transportation require changes either to the transportation system itself or to citizens' behavior, perhaps induced by providing information or pricing incentives (for instance, better information about public transportation, or congestion charging).

Piloting New Technologies

The Climate Group's LightSavers programme is an excellent example of piloting to support the replacement of existing technology with more efficient alternatives. When a better lighting solution exists, there are potentially many reasons why it is not adopted, including low awareness, lock-in to a long procurement process, agency issues where investors won't see the benefits of solutions, and basic lack of awareness of the new solution's track record in deployment.

In the case of LightSavers, The Climate Group used a technology-diffusion framework adapted from Everett Rogers' work (Rogers 1983). Called the 5As framework, it helped to design a process for supporting cities in trialling new solutions and developing confidence for those to be scaled up.

Technologists will learn more about their product when they move from laboratory testing to real-world conditions. The LightSavers pilots were set up to support procurement managers of outdoor street lighting, usually in the transportation departments of cities, to design trials that could help them build their own knowledge of how the new LEDs would function under real outdoor conditions. It was then possible to assess, at relatively low expense, which products functioned best for

[7]http://cordis.europa.eu/fp7/home_en.html

Awareness	Are markets, potential users, and policy makers aware of the technology potential and the present stage of development? Is the learning from pilots being shared sufficiently with potential users? What are the gaps to awareness?
Availability	Is the technology available locally to pilot-test and scale up significantly?
Accessibility	Do existing policies or market imperfections constrain the user from adopting solutions even when they are available?
Affordability	Can the technology compete on price with the appropriate support? What is the business case for procurement? Can innovative financing overcome lack of capital?
Acceptance	Is the new solution finally accepted as a viable alternative to existing methods?

FIG. 1
The 5As Framework

the city in question, and to build confidence in a larger procurement as the next step.

In trials around the world that replaced existing lighting with LED luminaires and tested the lighting quality using the same methodology, the findings were:[8]

- LED luminaires provide equivalent illumination to High Intensity Discharge (HID) at half the energy use, with even better performance from smart controls.
- There is excellent lumen maintenance for some products.
- There is excellent color stability for most products.
- On-site system effectiveness due to directionality of LED light accounts for much of the energy savings.
- Early indoor applications have a strong business case.

In China and India in particular, these early trials are leading to large procurements of LEDs that will significantly reduce emissions from outdoor lighting in those cities.

Piloting New Models, or Modifying Existing Services

The Internet and the devices that connect to it are changing our economy. McKinsey recently found that the Internet contributes 3.4 percent to GDP, more than energy or agriculture, and it has contributed 21 percent of GDP growth in the last 5 years, a dramatic rise from the previous decade. It also contributes 2.6 jobs for every one lost due to technology, with 75 percent of the benefits going to other sectors (Pelissie et al. 2011).

The Climate Group's partnerships to pilot new services emerged from our work on the enabling role of ICTs. The Internet, together with laptops, printers, mobile phones, and the networks and data centres that support them, are estimated to account for 2–3 percent of global emissions. However, if used appropriately, they may also help make existing activities more efficient or allow new options for services to become possible. In 2008, the *SMART 2020* report showed that 15 percent of global emissions could be saved in 2020 through ICT-enabled energy efficiency, by making buildings, transportation, industrial processes, and the electricity grid more efficient (Climate Group 2008).

For instance, smart metering solutions provide many new capabilities beyond the existing "dumb" meters. The benefits discussed from smart meters include their network effects, otherwise known as the smart grid: With dynamic information available about the "last mile" of electricity, gas, or water networks, it is possible to better match energy supply with demand. Citizens can in theory see real-time feedback about their actions. And utilities can manage increasing intermittent sources of power (such as wind) more effectively.

Cities have become the site for solution trials because it is in the city that transportation, buildings, and electrical systems intersect, and therefore where much of the *SMART 2020* potential can be realized. As noted in Chapter 3 of this report, broadband digital infrastructure can interconnect people and city systems, allowing cities and their residents to respond to changing circumstances nearly in real-time.

[8] Final report, LightSavers, forthcoming 2012

Cisco's Connected Urban Development (CUD) program[9] has conducted pilots to demonstrate the role of ICTs in saving greenhouse gas emissions, such as "smart work" solutions that help people avoid travelling at peak traffic times and help employers increase occupancy in buildings.[10] Some of these ideas are beginning to take hold more widely. In a recent survey of C40 cities, new ICT-enabled initiatives such as smart grids, cycle rental schemes and real-time traffic information provision are being rolled out in about one-third of the cities (C40 and Arup 2011).

However, there are a number of reasons why these solutions are difficult to implement at scale, as we found in the recent report *Information Marketplaces*:[11]

- Smart city plans that are technology-led run the risk of compromising development plans. Smart metering is a case in point: in U.S. markets, a technology-driven approach has led to a backlash amongst consumers who do not see the benefits of energy savings that were promised. The presence of smart meters alone does not deliver the benefits promised; it is when a critical mass of them are deployed and services are running on their data that consumers will see the value.

- The value of digital investments is not being clearly articulated for all stakeholders. Cities may be unsure of the payback or may not possess mechanisms to pay for up-front costs even if payback is certain in the long term.

- Objectives for each economic actor may not be aligned with social, economic, or environmental value for the city and citizens.

- Cities are complex organizations, and decisions that involve multiple departments can take time and can often be at odds with the sales cycles of companies. Procurement cycles for cities can take up to three years from initiation to sale, which can prevent innovative—and usually under-resourced—companies from participating in smart city development opportunities .[12]

Overcoming these barriers involves designing pilot projects that test demand for solutions in the market, not only the better *supply* of technology. The presence of ICT alone is not enough to ensure emissions savings; these tools need to be applied to change processes or behavior if emissions are to be saved.

Therefore, a piloting approach is needed which tests the applications of the network, not only whether the technology is working in the field as expected or to technical standards. As John Seely Brown and Paul Duguid argue in their book The *Social Life of Information* (2000), learning is demand driven, and technologies are dependent upon social norms and contexts. "Learning is usually treated as a supply-side matter.... But learning is much more demand driven. People learn in response to need ... when they have a need, then, if the resources for learning are available, people learn effectively and quickly."

This network makes it possible to learn rapidly, aggregating demand from numerous disparate individuals. Pilots need to be designed to under-

[9]The Climate Group partnered with CUD to bring learning from pilots to a wider audience and transitioned the work to the SMART 2020 initiative, http://www.theclimategroup.org/our-news/news/2009/9/28/cisco-and-the-climate-group-to-develop-new-connected-urban-development-alliance/

[10]http://www.connectdurbandevelopment.org

[11]Climate Group, Arup, and Accenture. 2011. *Information Marketplaces: The New Economics of Cities.*

[12]http://theclimategroup.org/our-news/news/2011/11/3/twenty-global-cities-launch-technology-award-to-improve-the-living-standards-of-100-million-citizens/

stand how the network applied to a particular challenge will alter behaviors, what will be the potential uptake of services, what new or existing economic actors will be involved, and the business models or partnership models required to scale up the solution. It is the outcome of these interactions with technology that will save emissions or provide low-carbon alternatives to high-carbon activities.

An emerging model for demand-led solution piloting is the "challenge" or prize approach. Nobel Prizes have long rewarded innovation in science for society, and more recently technology X Prizes have galvanized individuals to invest in problems to which no one has yet found the answer. Though the X Prize can be criticized for leading to duplication in effort, with only one winner taking the prize when competitors should also be rewarded for their time and effort, it does create urgency and a process for rapid learning.

The Living Labs Global Award has applied the challenge model specifically to the city piloting context. The award is designed around the insight that cities are reinventing the wheel. They are struggling with challenges other cities have faced and are looking for home-grown solutions.

Therefore, the first step in becoming a participating city in the Living Labs Global Award is to openly declare a challenge and demonstrate willingness to look globally for products and solutions. Once the city has announced its intention to solve its challenge, the Living Labs Global Award process takes the city on a journey of discovery and evaluation of solutions that have been implemented elsewhere. The city appoints a jury, which will choose in an appropriate solution for that city—not necessarily the most technically advanced solution.

In 2011, the third year of the prize, 20 cities have announced challenges[13] that could reach 75 million citizens globally. Cities will award the winning solutions providers with the potential to develop pilot projects in their city. The Living Labs Global model has been designed for cities seeking "smart" or "intelligent" solutions, and not all are directly related to sustainability or climate change.[14] But many are: Lagos is looking for inexpensive smart homes that can be deployed rapidly and help the city provide better services to residents; Santiago de Chile is looking for innovative parking solutions to reduce environmental impact from congestion.

Key principles of the approach that may be replicated in other piloting schemes are as follows:

- ***Start from the demand-side:*** A city's challenge leads the process.
- ***Help companies identify likely prospects:*** By identifying cities ready to tackle a challenge, solutions providers can more quickly identify which of the 557,000 local authorities are likely to be interested in a solution.
- ***Provide a pre-procurement learning process for cities:*** Cities will see where the solution has been implemented before, thereby providing new options for cities to choose solutions they may never have envisioned
- ***Shorten the solution providers' time to market:*** Procurement can take 18 months to 3 years, and slow citizens' access to new services. By raising awareness of the solution in the context of a city's challenge, it is possible to accelerate the solution's diffusion curve.

[13] http://www.llga.org

[14] The Climate Group is partnering with Living Labs Global Award to bring climate and energy expertise to the process, http://www.theclimategroup.org/our-news/news/2011/11/3/twenty-global-cities-launch-technology-award-to-improve-the-living-standards-of-100-million-citizens/

- *Encourage place-based innovation:* Allow the city and company to work together defining a pilot that is geographical. (When a new service is tested, it is important to test the business model as much as the solution itself. Therefore, the pilot may need to occur not simply at solution level but at neighbourhood level.[15])

One of last year's Living Labs Global Award winners, a parking solution for Helsinki,[16] is one example of a new way of thinking about parking—"directed" parking. It is scalable to other cities and has the potential to save emissions and time, all while providing revenue for citizens, businesses, and the city. The platform creates a marketplace for parking spaces that lets individuals sell their spots if they are away, or would let restaurants offer parking along with dinner reservations. Cities can calculate their earnings from better access to public parking spots or the emissions saved from vehicles that go straight to a parking spot instead of circling for many polluting minutes. While this solution relies on a range of technologies (the network infrastructure, mobile phones, a billing and booking system, and data applications), the service's success requires a business model that provides incentives for people to change their behavior. The pilot project will need to test the business model in the city context.

The Living Labs Global Award process demonstrates how cities can attract innovative climate and sustainability solutions that are contextual, demand-driven, and use the power of the network to hasten the learning process.

[15]Dennis Frenchman, Michael Joroff, and Allison Albericci. 2011. *Smart Cities as Engines of Sustainable Growth*. Washington, DC: World Bank Institute.
[16]SpotScout Beta, http://www.spotscout.com/scout/

Achieving Outcomes: Scale-Up of Pilots

Many challenges to sustainability and green growth in cities remain, even if successful pilots are underway. Investors are not always the beneficiaries of solutions, as we see in buildings where owners do not manage the day-to-day operations. Lack of skills (or the need to retrain) as new technologies and solutions emerge has to be considered early, or solutions will remain in the nascent stage. Changes in behavior are difficult to predict, and infrastructure choices may lock in high-carbon behaviors for years to come.

What both the piloting approaches above have in common is that a group of cities are piloting at the same time. In each case, sharing the learning is a key part of bridging information gaps and building confidence in expanding solutions to more citizens.

In the case of the LightSavers trials, cities that pilot in parallel can share technical knowledge and compare results in different cities. Certain luminaires may work better in certain climates. Particular configurations of street lighting may lend themselves better to one product or another.

In the case of Living Labs Global, the concentration of city challenges generates huge interest amongst service providers and allows each city to benefit from the awareness raised about the award process. Living Labs Global is also able to research multiple solutions at once and to generate independent evaluation data across thousands of solutions that can be used by all the cities, essentially creating a global marketplace for solutions.

Cities are the laboratories of the transition to a Clean Revolution. Innovation and pilot project scale-up will require significant investment and changes in governance and financing that we have only begun to grapple with. The successful transition is inextricably linked with governance, institutional, and organisational change to ensure that learning is shared, pilots are not repeated unnecessarily, and scaling the solutions is possible.

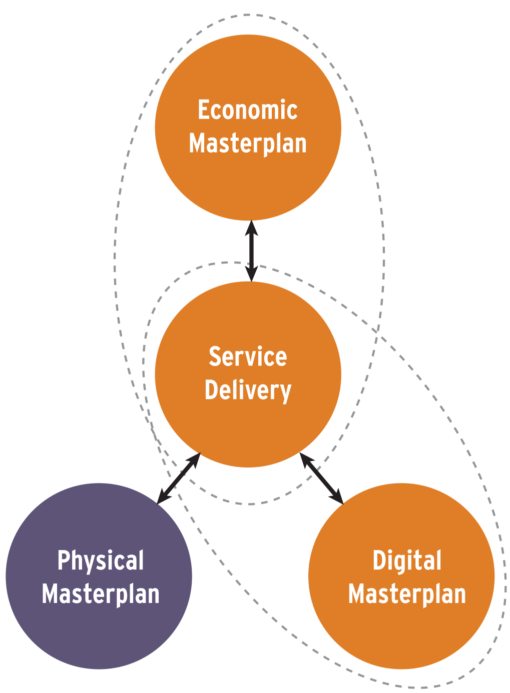
ANNEX 15
The Role of Technology in City Master Planning

Technology is beginning to transform the way cities are structured, the way people communicate and work, and the way resources are managed—yet within cities, technology is rarely adopted in a fully integrated and strategically designed manner. The traditional approach to city planning has focused on the physical; today, additional planning around the city's digital infrastructure is required to enable long-term sustainability. Defining the city's digital and ICT requirements, such as high-speed broadband connectivity and open application architecture, alongside the city's physical blueprint (for example, land use zoning and transport planning) and economic planning (for example, industrial sector strategy and taxation strategy) will enable more efficient, integrated services to be provided to citizens. Such a multi-disciplinary approach to urban planning is practiced by the business and technology consulting firm Accenture (Figure 1), which focuses the physical-digital-economic master planning of a city around the services required to meet the needs of its citizens and businesses.

By planning and deploying technology at the city level, managers can realize economies of scale across departmental silos, such as energy, buildings, and mobility. For example, smart grids are bringing together our energy and telecommunication grids, and electric vehicles are connecting our transport systems with our energy networks—making both energy and transport data more accessible. In addition, technology enables a city to provide new cross-industry services. In Singapore, for example, rainfall often comes in intense, localized downpours, which increases congestion in the city and makes it very difficult to find a taxi. The Massachusetts Institute of Technology combined data on weather forecasts, GPS taxi locations and mobile phone cell propagation to understand, in real time, how rainstorms will affect the city and to co-locate taxis to the high-demand areas. By using existing technologies in an integrated fashion, the city has been able to provide a useful new service to citizens and to better plan its resources; and citizens are able to get a cab even when it's raining.[17]

To realize the full potential of technology, cities need to adopt a combination of hard and soft infrastructure. Hard infrastructure includes the city's physical ICT assets (data-center capacity, smart grids, connectivity and bandwidth, software, and data visualizations), and soft infrastructure involves tools to manage these assets (business and governance models, citizen engagement, and a strategic focus on ICT). Cities today are already making investments in hard infrastructure, such as smart transport and smart grid projects, to drive

FIG. 1
An Integrated Approach to City Master Planning



[17]http://senseable.mit.edu/livesingapore/

economic and environmental benefits. However, their approach tends to be fragmented across city departments. On the soft-infrastructure front, local and national governments need to understand the role they want to play in relation to the city's data and digital assets, and they need to establish leadership capabilities—in the form of a Chief Information Office (CIO), for example—to set the strategic ICT direction for the city and to put in place appropriate frameworks and incentives to enable the digital economy to flourish. Placing an equal emphasis on soft and hard infrastructure will enable cities to create long term socioeconomic and environmental value. The framework below (Figure 2) shows the different levels of implementation that cities can achieve in terms of their hard and soft infrastructure; it highlights that, while the smart city concept is becoming well-known, the vast majority of cities are far from implementing the infrastructure required to reap the full sustainability benefits of smart technology.

Setting a single set of metrics at the city level will also enable cities to evaluate the success of sustainability initiatives on a like-for-like basis. For instance, smart grid projects are measured by a reduction in energy losses and efficiency gains, and variable road pricing schemes are measured by reduced traffic congestion. While the value of each project can readily be assessed at the departmental level, it is less easy to understand the contribution of the project to the city's overarching objectives. For example, how would a city compare the relative value contributed by a smart grid with

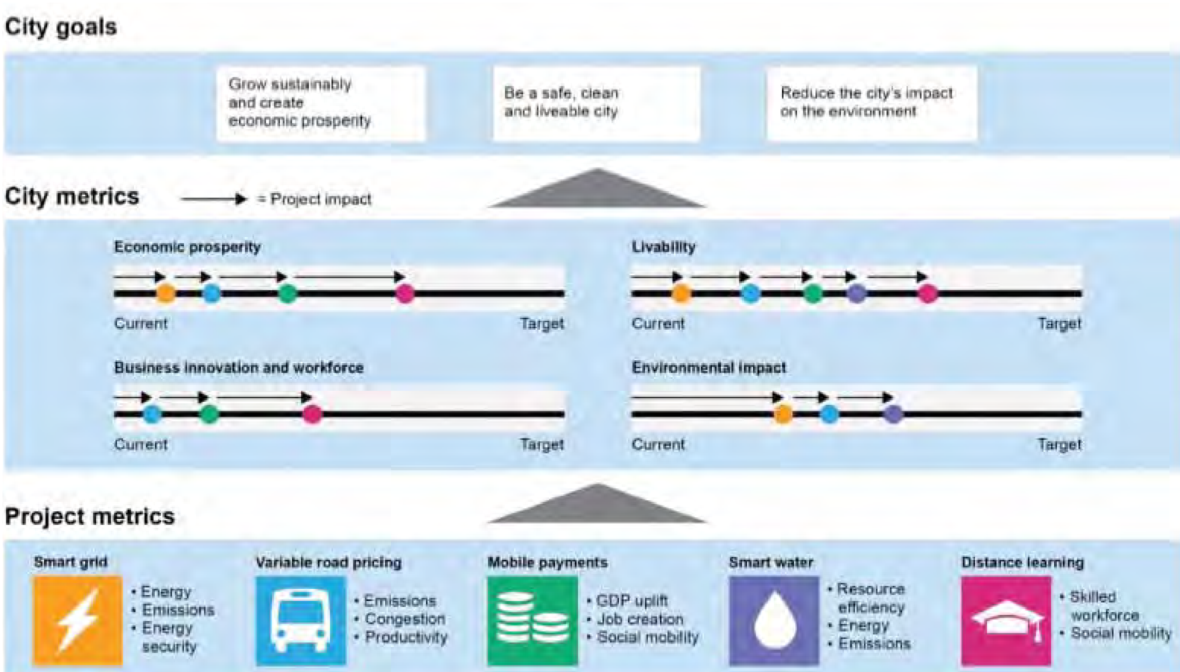
Smart City Project Implementation	Level 1	Level 2	Level 3	Level 4
Soft Infrastructure				
Value Assessment	Individual project business cases	Some non-financial value assessed	Holistic value assessment (social/environmental/financial)	Holistic value assessment supporting diversification of funding sources
Governance	Departmental governance structures	Some cross-departmental collaboration	Cross-departmental 'Smart City' management positions in place	City-wide governance structures and shared performance targets combined with international collaboration
Strategic ICT Focus	Limited ICT capability	Some strategic focus on ICT	ICT vision for the city	ICT vision and strategy overseen by dedicated City CIO
Citizen Engagement with Service Design	Limited citizen engagement	Project-level, basic needs analysis, pilots	Citizen feedback loops established	Citizen participation in integrated service design
Hard Infrastructure				
IT project focus	Little or no ICT projects	Targeted ICT project investments (e.g. Smart Grid)	Integrated ICT investments (including embedded sensing, control and actuation)	Real-time city operations optimisation
Integration of Data Streams	No data integration	Small scale data integration	Creative data mash ups pulling data to a common platform	Open data and crowd-sourcing initiatives
Digital Service Provision	Little or no digital service provision	Handful of digital services	Integrated digital services around the city environment	Diversity of cloud-based citizen services

FIG. 2
Framework for a Smarter City

Source: Reprinted from The Climate Group, Accenture, Arup, and The University of Nottingham. *2011. Information Marketplaces: The New Economics of Cities.*

that contributed by variable road pricing toward its city-wide aims of economic development, livability, and environmental sustainability? Such questions present a challenge to city leaders who need to make capital allocation decisions across a portfolio of initiatives. For the value of initiatives to be effectively compared, a common suite of metrics needs to be developed that ties the performance of individual initiatives to the city's long-term strategic aims. A single city scorecard, based on specific objectives, will enable the city to understand the relative value of different initiatives based on how well each delivers on the city's overall strategy.

FIG. 3
Measuring Urban Sustainability Initiatives Against a Common Set of Metrics



Source: Reprinted from The Climate Group, Accenture, Arup, and The University of Nottingham. *2011. Information Marketplaces: The New Economics of Cities.*

ANNEX 16

Eco² Cities: Ecological Cities as Economic Cities[18]

Eco² Cities is an initiative launched by the World Bank in 2010 as an integral part of its Urban and Local Government Strategy, to help cities in developing countries achieve greater ecological and economic sustainability.

Ecological cities enhance the well-being of citizens and society through integrated urban planning and management that fully harnesses the benefits of ecological systems, and that protects and nurtures these assets for future generations. Economic cities create value and opportunities for citizens, businesses, and society by efficiently using all tangible and intangible assets, and enabling productive, inclusive, and sustainable economic activity.

What is an Eco² City?

An Eco2 city builds on the synergy and interdependence of ecological and economic sustainability, and their fundamental ability to reinforce each other in the urban context. Innovative cities in both the developed and the developing world have demonstrated that with the appropriate strategic approach, they can enhance their resource efficiency—realizing the same economic value from a much smaller and renewable resource base—while simultaneously reducing harmful pollution and unnecessary waste. By doing so, they have improved the quality of life of their citizens, enhanced their economic competitiveness and resilience, strengthened their fiscal capacity, and created an enduring culture of sustainability. Many of their interventions have also provided significant benefits to the poor. Urban sustainability of this kind is a powerful and enduring investment that will pay compounding dividends. In a fast-paced and uncertain global economy, cities that adopt such an integrated approach are more likely to survive shocks, attract businesses, manage costs—and prosper. The Eco2 Cities Initiative was developed to enable cities in developing countries to realize this value and to and take on a more rewarding and sustainable growth trajectory while the window of opportunity is still open to them.

Unique Features of the Eco² Cities Initiative

The Eco² Cities Initiative provides cities with an analytical and operational framework that can be applied and contextualized to the particular challenges of each city. The framework also includes methods and tools that make it easier for cities to adopt the Eco² approach as part of their city planning, development, and management. The Eco² Cities Initiative also assists cities in developing countries to gain access to financial resources needed for strategic urban infrastructure investments.

Another important feature of Eco2 is its bottom-up approach. Innovative best-practice cities around the world have demonstrated how ecological and economic progress can go hand in hand. Eco2 elements systematically build on these global best practices.

How The Eco² Cities Initiative Works

The Eco² Cities Initiative works through the application of an analytical and operational framework that helps cities systematically achieve positive results. As a framework, it provides a point of departure and needs to be customized to the particular context of each city.

After careful assessment of cities that have benefited tremendously from this sort of approach,

[18]Eco² Cities Synopsis, http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1270074782769/Eco2Cities_synopsis.pdf

as well as a detailed look at the major challenges that have prevented similar achievements in most other cities, the framework has been structured around four key principles that were found to be integral to lasting success. These principles are the foundation of the Eco^2 initiative. Each principle is widely applicable, critical to success, and frequently ignored or underappreciated:

PRINCIPLES	CORE ELEMENTS
A city based approach	• A development program that supports cities in making good decisions and implementing these decisions using all levers of city influence and control • A planning philosophy that recognizes the fundamental role played by local ecological assets in the health and wealth of cities and their surrounding rural communities • An action-oriented network that provides city leaders with the full support of national governments, the international development community (including the World Bank), and global best practice cities • A decision support system with methods and tools that adapt to varying levels of knowledge and skill and provide cities with the technical, administrative, and financial capacity to develop an Eco^2 pathway
An expanded platform for collaborative design and decision-making	• A three-tier platform that enables a city to collaborate (1) as a model corporation, engaging all city departments; (2) as a provider of services, engaging residents, businesses, and contractors; and (3) as a leader and partner within the urban region, engaging senior government officials, utilities, rural settlements, private sector stakeholders, nongovernmental organizations, and academia • A shared long-term planning framework for aligning and strengthening the policies of the city administration and key stakeholders and for guiding future work on Eco^2 projects
A one system approach	• Integrated infrastructure system design and management focusing on enhancing the efficiency of resource flows in an urban area • Coordinated spatial development that integrates urban forms with urban flows, combining land use, urban design, urban density, and other spatial attributes with infrastructure scenarios • Integrated implementation by (1) correctly sequencing investments, (2) creating a policy environment that enables an integrated approach, (3) coordinating a full range of policy tools, (4) collaborating with stakeholders to align key policies with long-term goals, (5) targeting new policies to reflect the differing circumstances involved in urbanization in new areas and in improving existing urban areas
An investment framework that values sustainability and resiliency	• Incorporation of life-cycle costing in all financial decision making • Equal attention to protecting and enhancing all capital assets: manufactured capital, natural capital, social capital, and human capital • Proactive attention to managing all kinds of risk: financial risk, sudden disruptions to systems, and rapid socioeconomic environmental change

The four principles are interrelated and mutually supportive. Without a strong city-based approach, it is very difficult to fully engage key stakeholders through an expanded platform for collaborative design and decision-making. And without this expanded platform, it is difficult to explore creative new approaches to the design and management of integrated systems, and to coordinate policies to implement through the one system approach. Prioritization, sequencing, and effectiveness of investments in sustainability and resiliency will be greatly enhanced by appreciating the city as one system and expanding the platform of collaboration.

A set of core elements have been derived through these principles. Each city may transform the core elements into a series of concrete action items or stepping stones that take into account local conditions and follow a logical sequence. Together, these stepping stones enable a city to develop its own unique action plan, called an Eco2 pathway (Figure 1). The Eco^2 Cities Initiative also introduces cities to methods and tools that will lead to more effective decision-making through powerful diagnostics and scenario planning. These methods and tools can also be used to operationalize the core elements and implement the stepping stones.

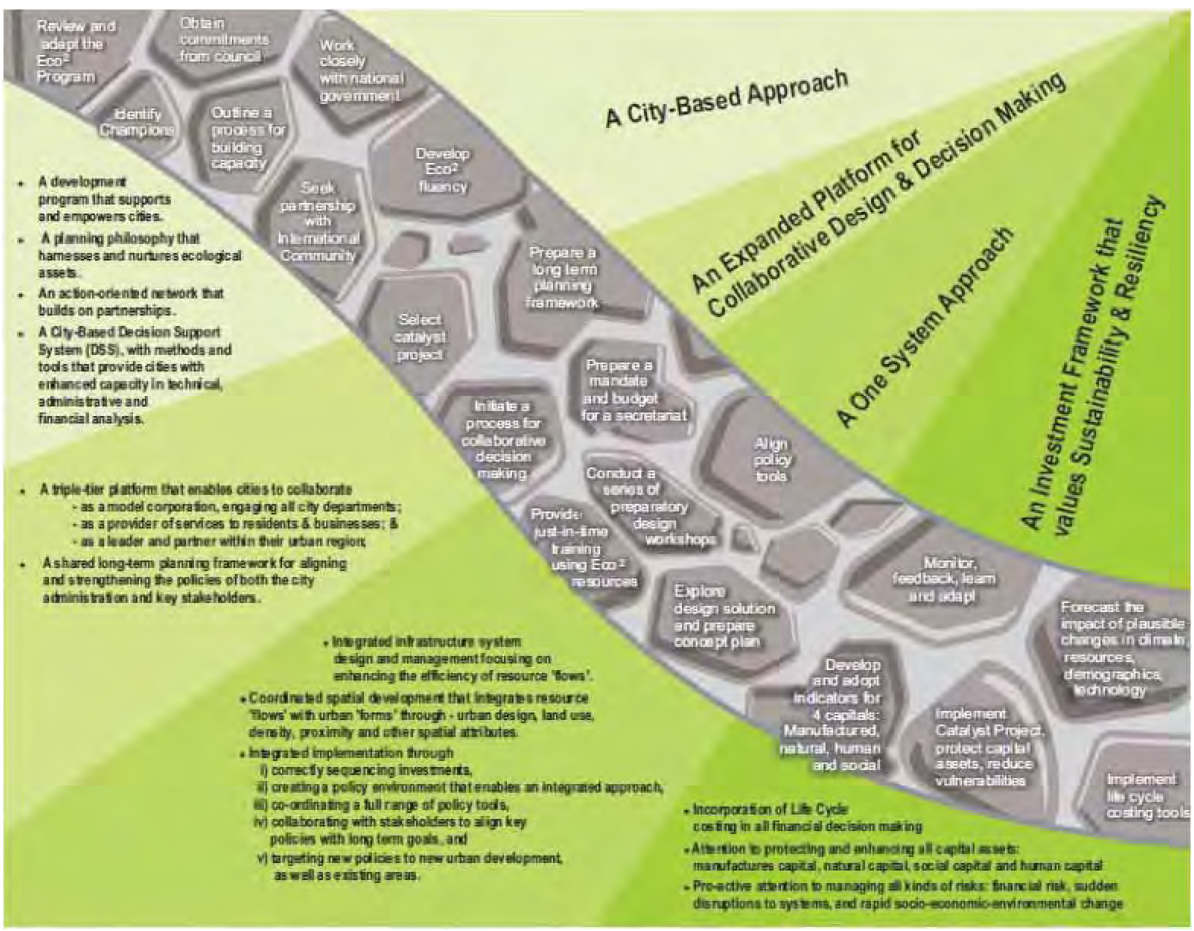


FIG. 1
Example of a Phased, Incremental Eco^2 Pathway

In this context, the ideal situation is when a city adopts the four key principles, applies the analytical and operational framework to its particular context, and, by doing so, develops and begins to implement its own sustainability pathway. Cities may begin incrementally, by engaging in capacity building and data management and by initially targeting their most critical priority through developing and implementing an Eco^2 catalyst project. Unlike stand-alone projects in resource efficiency, a catalyst project is distinguished by an explicit objective and an ability—beyond the immediate project scope and objectives—to drive the city forward on its sustainability pathway by catalyzing the process of change.

Moving Forward Together

The World Bank is currently collaborating with cities in developing countries, their national governments, the international community, global best practice cities, multilateral and bilateral development agencies, academia, the private sector, and NGOs. As pilot Eco^2 Cities in developing countries conceptualize and implement their own Eco^2 pathways, we hope to channel their support to other cities beginning their own Eco^2 pathway. At present, national knowledge-sharing and capacity-development activities are being implemented under the Eco^2 framework in Indonesia, Vietnam, and the Philippines.

ANNEX 17
Sustainable Development Goals

To achieve the goals of Rio+20 in an ambitious, time-bound and accountable manner, we call upon governments in accordance with human rights, the principle of common but differentiated responsibilities, and respective capabilities to adopt the following draft Sustainable Development Goals together with the sub-goals, reasons and clarifications relating to each goal:

The goals below are aspirational. While some of these are based on commitments already made by governments and other stakeholders, others are proposed on the basis of advanced thinking among civil society organizations.

1. Sustainable Consumption and Production
2. Sustainable Livelihoods, Youth & Education
3. Climate Sustainability
4. Clean Energy
5. Biodiversity
6. Water [Efficiency]
7. Healthy Seas and Oceans (Blue Economy)
8. Healthy Forests
9. Sustainable Agriculture
10. Green Cities
11. Subsidies and Investment
12. New Indicators of Progress
13. Access to Information
14. Public Participation
15. Access to Redress and Remedy
16. Environmental Justice for the Poor and Marginalized
17. Basic Health

Source: Reprinted from Rio+20 UN Conference on Sustainable Development website, http://www.uncsd2012.org/rio20/index.php?page=view&nr=273&type=230&menu=38

ANNEX 18

Earth Observation for Urban Monitoring

What Urban Parameters Can Be Measured With Earth Observation?

The basic Earth observation (EO) datasets that are relevant to urban areas are land cover maps and their changes over time. These maps characterize the extent of urban areas, together with the spatial and temporal distribution of specific urban land uses (such as housing, industry, green areas, and so on). An example of an existing database with information on land use and land cover changes is the European Coordination of Information on the Environment (CORINE) program, and more specifically the Urban Atlas, a CORINE component dedicated to urban mapping. Urban Atlas maps are developed at a geometric resolution of 1:10,000, with a minimum mapping unit (MMU) of 0.25 hectares within the built-up urban areas, and a lower resolution of 1-hectare MMU outside urban centers. They are produced with 22 urban and 4 non-urban classes, which offers significantly better resolution than the CORINE classes (Figure 1).

Making Use of Earth Observation Capabilities

It is estimated that public institutional users generate more than 80 percent of the market demand for earth observation data and services (Keith and Bochinger 2009). Free or low-cost EO data solutions are preferred, where available. However, a significant step forward for the application of EO to urban development monitoring was the availability of commercial high- and very-high-resolution (VHR) optical satellites with a pixel size of 0.5–5 meter. This provides better information accuracy, delivery time, and continuity of datasets. In addition, the recent launch of very-high-resolution synthetic aperture radar (SAR) commercial missions in Europe and Canada is pushing forward a range of applications in the urban risk-management domain (for example, assessing risks of flooding, land subsidence, and landslides). This development is of interest both to the public sector (for example, civil protection authorities and local municipalities) as well as to the private sector (for example, insurance and engineering firms).

The European Urban Atlas is another example of an operational EO application that provides homogeneous and up-to-date information on more than 300 European cities. It offers comparable information on the density of residential areas, commercial and industrial zones, the extent of green areas, exposure to flood risks, and monitoring of urban sprawl (essential for public transport and infrastructure planning in urban and peri-urban areas). This type

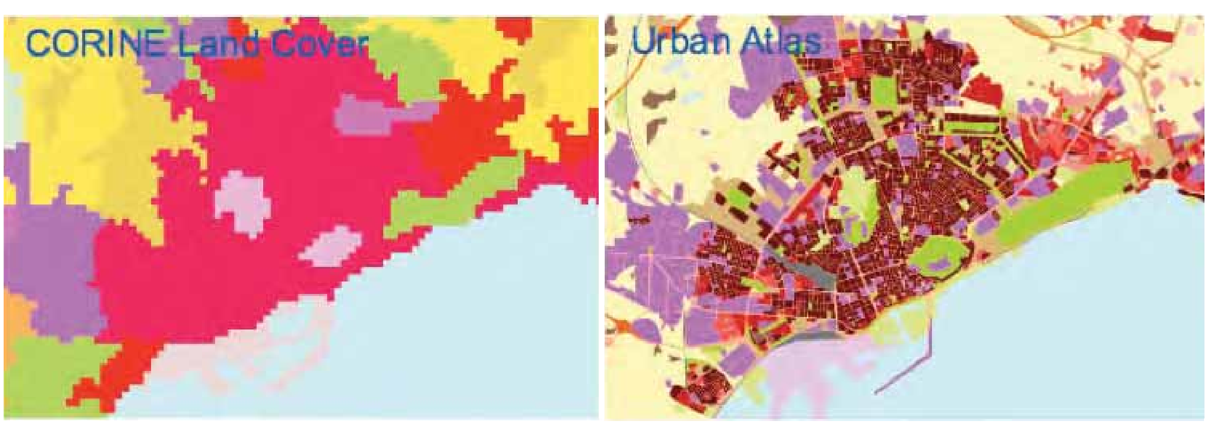


FIG. 1 Comparison of CORINE Land Cover Map with an Urban Atlas Map for the Same Area

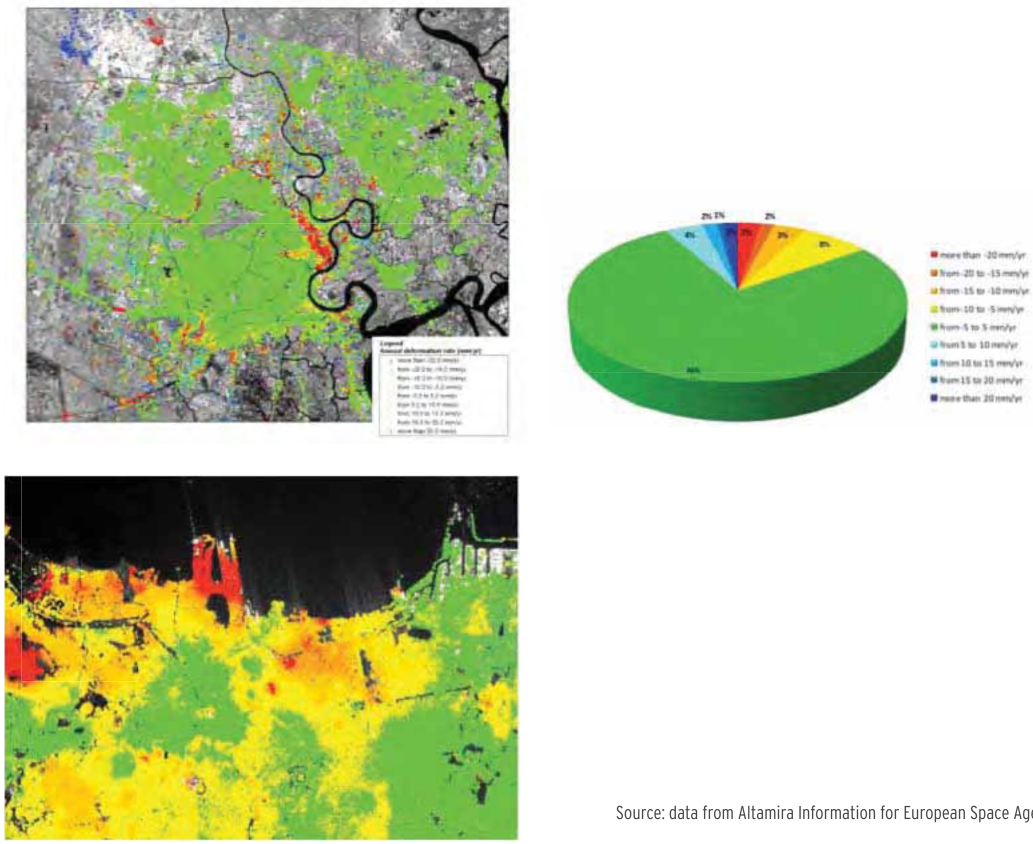


FIG. 2
Monitoring Urban Infrastructure Subsidence in Ho Chi Minh City and Jakarta using Satellite-Based PINSR Interferometry (SAR)

Source: data from Altamira Information for European Space Agency and World Bank.

of information is routinely used by city governments and other European institutions such as DG REGIO, DG ENV, and the European Environment Agency.[19] At present, the Urban Atlas maps are also being used to produce a set of derived city indicators (for example, land cover and use, green urban area per inhabitant, urban sprawl index, and so on). In addition, they are being used as input data for the modeling of urban vulnerability to natural hazards.[20]

The combination of EO and other datasets can answer many and varied policy questions, such as:

- How are cities changing over time?
- How much, and in what proportion of uses, is land being consumed for urban development?
- Where are the areas with the most significant land use change?
- What are the drivers of urban and other land development, and what new infrastructure will be needed to support this development?
- What are the possible effects of natural disasters, and how much of the population and assets will be affected?

Use of Earth Observation in Urban Disaster Risk Management

To support disaster risk management, high-resolution optical and radar imagery can be used in combination to map and identify physical changes in urban centers resulting from natural disasters. This can be done for entire urban zones, or at the level of individual buildings.

A unique capability of SAR is to measure changes in the land surface position to high accuracy using a long time-series of EO data. This method is being used to measure land subsidence (Figure 2), land disturbances following earthquakes, and the dynamics of

[19] http://dataservice.eea.europa.eu/map/UrbanAtlasBeta/
[20] http://moland.jrc.ec.europa.eu/evdab/HTML/home.html

FIG. 3
Flood Risk Scenarios Developed for Rio de Janeiro

Source: software and data from European Space Agency and World Bank.

active volcanoes. With the new very-high-resolution commercial radar missions, the motion and stability of individual buildings and structures can be measured to an accuracy of a few millimeters per year. This type of information is providing major new insights into identifying and understanding urban risk.

Finally, the combined use of Earth observation satellite imagery (optical and radar), in situ data, and advanced modeling techniques can support different phases of the urban risk-management cycle with assessments of exposure of specific infrastructure to multi-hazard risk, as well as the level of potential loss. For example, the EO-based flood simulation conducted for the watersheds of Rio Grande and Rio Anil in the Municipality of Rio de Janeiro (Figure 3) improved the understanding of the consequences of land cover changes vis-à-vis different land use scenarios, the number of inhabitants affected by floods, and the amount of time available for the civil protection authorities to respond in case of emergency. This type of information can be useful in formulating disaster prevention strategies.

Future Directions in Earth Observation Capabilities

Web-based Earth observation together with GIS has opened new possibilities for developing specialized applications that are relevant to decision makers. In the European space sector, the Global Monitoring for Environment and Security (GMES) flagship program is being implemented in partnership between the European Union and the European Space Agency (ESA). GMES comprises a fleet of EO satellites, a system that was purpose-built for the provision of operational information services in the Land, Marine, Humanitarian Aid, Atmosphere, and Security domains. The system (developed through ESA) will provide long-term (decadal) data continuity, which is key to achieving widespread use and acceptance of EO-based information services. In terms of information on the urban environment, a multispectral high-resolution imaging mission (10-meter resolution) for land monitoring will provide continuous SPOT- and Landsat-type data for vegetation, soil, and water cover, inland waterways, and coastal areas. GMES has the capability to observe global land cover at 10-meter resolution every five days, representing an unprecedented source of information that can be tapped. Furthermore, the GMES Sentinel Data Policy is based on principles of full and open access, setting the trend in future data policies around the world.

It is evident that EO can provide a wealth of information related to the monitoring of urban areas and the development of larger urban agglomerations. Such information is being used operationally by a number of institutions, and the new European GMES initiative will soon bring enhanced capabilities. A comprehensive assessment should be carried out to determine exactly what and how these new sources of information can contribute to key activities in the urban domain and the promotion of sustainable cities.

ANNEX 19
Publishing City Information
A Proposed 'South African Cities Accord'

The World Bank released the report Cities and Climate Change: An Urgent Agenda at COP16 in Cancun, December 2010. This included a press conference, a press release, printed copies, and placement of the report on the Bank's external website. The report included a table compiling city-based per capita GHG emissions for some 100 cities, 45 of which were suggested to be sufficiently comparable having been peer reviewed within the academic community. Public pick up of the report was considered good, but relatively modest.

The same table was included in a paper in the April 2011 edition of the journal Environment and Urbanization. This time however the paper's publication was accompanied by an IIED press release drawing attention to the 'ranking of cities' the table facilitated. The press release was picked up by more than 200 media outlets, and translated into more than 10 languages.

One media outlet that picked up the IIED press release was a local newspaper in Cape Town. The front page of the local newspaper included a prominent headline highlighting that Cape Town's per capita GHG emissions were higher than London's. Considerable efforts by City Hall staff ensued, trying to explain the numbers and identifying an error in the reported values; Cape Town's GHG emissions were 7.6 tonne/capita, not the 11.6 t/cap reported in the article (despite obtaining values from a credible peer reviewed journal).

After extensive discussions between Cape Town and World Bank staff the values were corrected and important lessons on city data and publication emerged. Considerable city information is available. Similar to countries, most of which are smaller than these cities, this information needs to be published annually. The information is simply too important not to be readily available in the public domain. One of the proposals within this report is for the partners to publish the beast available data for at least the 100 largest urban areas every year. As this report highlights, this increased focus on cities is to be expected as policy makers, city dwellers, and city managers themselves further appreciate the enormous importance of cities.

Much of the recent focus on city information has been on GHG emissions. With the February 2012 announcement of an agreed C40-ICLEI protocol as supported by WRI, UNEP, UN-Habitat and the World Bank (now undergoing ISO standards development), this information should become more common and regularly published. Efforts to develop a common GHG standard and ensure regular collection and publication of data are illustrative. Cities need a simple process to collect and publish their data.

Sources of this information now include the Global City Indicator Facility (as supplied by participating cities), UNEP, PwC, UN-Habitat, IBNET, World Bank. However the best source for all city indicators remains the city itself.

City information is not 'owned' by anyone; similar to how banks collect our household financial data, doctors much of our health data, and schools our academic performance, our personal data is increasingly dispersed and amassed electronically. Certainly there are enormous privacy and accuracy issues, but cities need to have a clear policy on how 'open' they are willing to have their data. The data exists anyway, cities should therefore work to ensure that they control the accuracy and publication of city-based data.

The Global City Indicator Facility, as supported by agencies such as ICLEI, C40, UCLG, CDP, WRI, UNEP, UN-Habitat, OECD, World Bank, is structured to have as much control on data collection and publication by cities as possible. Efforts are also underway to have the methodologies subject to ISO standards — as with the recently announced GHG emissions protocol.

Cities are regularly approached by politicians, citizens, news media, and external agencies, to provide data. Many of these requests are duplicative. Almost all cities already have extensive data collection and publication programs. These programs however, would be benefit from consolidation and global harmonization where practicable. For example, when the GCIF was being established a detailed assessment of city indicators was completed for Sao Paul, Porto Alegre, Belo Horizonte, Bogota, Cali, Montreal, Toronto, and Vancouver. The eight cities were collecting some 1100 indicators annually – only 2 were in common. Obvious efficiencies are possible.

During COP17 in Durban, discussions were held with South African cities and a 'City Accord on City Data' was proposed by the cities of South Africa. The Accord would take advantage of the efforts of the Global City Indicator Facility (of which Cape Town, Durban and Johannesburg are members). So too would the Accord maximize linkages to organizations such as national city associations, C40, CDP, ICLEI, UCLG, Metropolis, etc. South African cities are well represented in membership of organizations such as C40 (Johannesburg) and ICLEI (African head office in Cape Town City Hall. GHG emissions are relatively well defined (e.g. Johaneburg, Durban, CDP efforts, and Cape Town's early participation in Carbonn). South African cities are also well represented in academic literature and ongoing research activities (e.g. IPCC participation, biodiversity programming, ecosystems services reviews). Finally, South Africa and its cities are uniquely placed to serve as a bridge across 'high, medium and low income' countries and their cities.

Reflecting the urgent need for a comprehensive and globally accepted city-led collection and publication of city indicators, a South African Cities Accord is proposed. The Accord would be led by the cities of Cape Town, Durban, and Johannesburg, and supported by the South Africa Local Government Association. A set of principles and common approaches are proposed:

- Cities should be given first opportunity to provide city indicator data.
- Cites (as defined as the constitutionally mandated most 'local government') should be given an opportunity to review data prior to publication.
- As much as possible data should be published to assist in policy development and observe regional and international trends, not to compare.
- Ideally all city data should first (or simultaneously) published by the city on their website or similar means.
- In larger urban areas each local government should collect and publish data and the urban area aggregated. Prior to all local governments participating in urban areas the main city, or alternative organization should publish the aggregated best available data.
- Data should be published annually with no more than a six-month delay in data collection, and six months of compilation and verification.
- All external organizations should defer to cities and their designated agencies such as

GCIF, however third party peer review, and ISO standardized definitions and approaches, should be available for all urban areas in excess of 1 million inhabitants.

- Ideally the collection and publication of city data should be an ongoing part of a city's management – the public disclosure should not place an undue burden on cities.

- For cities in low-income countries ongoing assistance for data collection and publication may be necessary, however the data as outlined in Table ## is considered to be sufficiently 'simple' for any city of 1 million-plus residents to regularly collect (many examples exist).

- Existing and new applications of remote sensing from urban areas should inform cities being monitored and ideally give cities the opportunity to review and comment on the information prior to publication (with at least a three-month review period).

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