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Capão Raso

GREEN economy

Cities

Investing in energy and resource efficiency

Acknowledgements

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List of acronyms

ARPU	Average revenue per user
BAU	Business-as-usual
BedZED	Beddington Zero Energy Development
BRT	Bus rapid transit
C40	Cities Climate Leadership Group
CDM	Clean Development Mechanism
CDS	City Development Strategy
CO_2	Carbon dioxide
CHP	Combined heat and power
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAR	Floor area ratios
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographic Information System
GLA	Greater London Authority
GNP	Gross National Product
HDI	Human Development Index
ILO	International Labour Organization
IOE	International Organisation of Employers
LSE	London School of Economics and Political Science
MTR	Mass Transit Railway
OECD	Organisation for Economic Co-operation and Development
PES	Payment for Ecosystem Services
R&D	Research and development
PV	Photovoltaic
UNEP	United Nations Environment Programme

Key messages

1. Urban development will have to fundamentally change to facilitate the transition towards a green economy. Urban areas are now home to 50 per cent of the world's population but they account for 60-80 per cent of energy consumption and a roughly equal share of carbon emissions. Rapid urbanisation is exerting pressure on fresh water supplies, sewage, the living environment and public health, which affect the urban poor most. In many cases, urbanisation is characterised by urban sprawl and peripheralisation – which is not only socially divisive, but also increases energy demand, carbon emissions and puts pressure on ecosystems.

2. Unique opportunities exist for cities to lead the greening of the global economy. There are genuine opportunities for national and city leaders to reduce carbon emissions and pollution, enhance ecosystems and minimise environmental risks. Compact, relatively densely populated cities, with mixed-use urban form, are more resource-efficient than any other settlement pattern with similar levels of economic output. Integrated design strategies, innovative technologies and policies are available to improve urban transport, the construction of buildings and the development of urban energy, water and waste systems in such a way that they reduce resource and energy consumption and avoid lock-in effects.

3. Green cities combine greater productivity and innovation capacity with lower costs and reduced environmental impact. Relatively high densities are a central feature of green cities, bringing efficiency gains and technological innovation through the proximity of economic activities, while reducing resource and energy consumption. Urban infrastructure including streets, railways, water and sewage systems comes at considerably lower cost per unit as urban density rises. The problem of density-related congestion and associated economic costs can be addressed and offset by developing efficient public transport systems and road charges.

4. In most countries, cities will be important sites for the emerging green economy. This is for three main reasons. First, the proximity, density and variety intrinsic to cities deliver productivity benefits for companies and help stimulate innovation. Second, green industries are dominated by service activity – such as public transport, energy provision, installation and repair – which tends to be concentrated in urban areas where consumer markets are largest. Third, some cities will also develop high-tech green manufacturing clusters in or close to urban cores, drawing on knowledge and skill spillovers from universities and research labs.

5. Introducing measures to green cities can increase social equity and quality of life. Enhancing public transport systems, for example, can reduce inequality by improving access to public services and other amenities, and by helping to relieve vehicle congestion in poorer neighbourhoods. Cleaner fuel for transport and power generation can reduce both local pollution and health inequality. Reducing traffic and improving conditions for pedestrians and cyclists can help foster community cohesion, an important aspect of quality of life, which also has positive impacts on economic resilience and productivity. Evidence shows that children who live in close proximity to green space are more resistant to stress, have a lower incidence of behavioural disorders, anxiety, and depression, and have a higher measure of self-worth. Green space also stimulates social interaction and enhances human well-being.

6. Only a coalition of actors and effective multilevel governance can ensure the success of green cities. The most important fundamental enabling condition is a coalition of actors from the national and local state, civil society, the private sector and universities who are committed to advancing the green economy and its urban prerequisites, placing it centrally within the top strategic priorities for the city. The central task of this coalition is to promote the idea of a long-term strategic plan for the city or urban territory. Equally, it is crucial to develop strategic frameworks not just at the local and urban level, but also at regional and national levels, ensuring coordinated design and implementation of policy instruments.

7. Numerous instruments for enabling green cities are available and tested but need to be applied in a tailored, context-specific way. In contexts with strong local government it is possible to envisage a range of planning, regulatory, information and financing instruments applied at the local level to advance green infrastructure investments, green economic development and a multi-track approach to greater urban sustainability. In other contexts, local governments, in a more pragmatic approach, could target a few key sectors such as water, waste, energy and transport and commit those to a limited number of specific goals as a point of departure for greening urban sectors.

1 Introduction

This chapter makes a case for greening cities. It describes the environmental, social and economic consequences of greening urban systems and infrastructure and provides guidance to policy makers on how to make cities more environmentally friendly.

An introduction to the concept of green cities is followed by Section 2, which presents related challenges and opportunities. Section 3 analyses the economic, social, and environmental benefits of city greening, while Section 4 summarises green practices across a number of urban sectors. Section 5 offers advice on enabling conditions for green cities. Section 6 concludes the chapter.

1.1 Cities

A city is a social, ecological, and economic system within a defined geographic territory. It is characterised by a particular human settlement pattern that associates with its functional or administrative region, a critical mass and density of people, man-made structures and activities (OECD and China Development Research Foundation 2010). Most commonly, cities are differentiated from other settlements by their population size and functional complexity (Fellmann et al. 1996). The definition of cities varies significantly from nation to nation, and is not always dependent on population size but can also reflect administrative or historical status (Satterthwaite 2008). The definition of urban areas tends to rely more on a population minimum but varies dramatically since it is dependent on unit size designations given by individual governments, which can range from minimum thresholds of 200 to 20,000 inhabitants upwards (UN Statistics Division 2008).[1]

1.2 Green cities

Green cities are defined as those that are environmentally friendly.[2] Indicators measuring environmental performance can include: levels of pollution and carbon emission, energy and water consumption, water quality, energy mix, waste volumes and recycling rates, green-space ratios, primary forests, and agricultural land loss (Meadows 1999; Brugmann 1999). Other indicators include the share of apartment living, motorisation rate, and modal share of urban transport. Another important measure of humanity's demand on nature is the Ecological Footprint (Ewing et al. 2010).[3] Defining green cities by their environmental performance does not mean social equity issues are ignored. In fact, and as detailed below, greener living environments can play an important role in making cities more equitable for their residents.

There are also existing cities that are referred to as green because of their ambitious green policies, a range of green projects and a principal trajectory towards a better environmental performance. A number of cities in western Europe, the USA and Canada have pioneered green strategies.[4] Freiburg, a city of 200,000 inhabitants in Germany, has a long tradition of sustainable building and investment in recycling and it reduced CO_2 emissions per capita by 12 per cent between 1992 and 2003 (Duennhoff and Hertle 2005). Several cities in developing countries, especially in South America, have also branded themselves green. Authorities in Curitiba, Brazil introduced policies to integrate land-use and transport planning and by the 1970s the city was equipped with an innovative bus rapid transit system (Economist Intelligence Unit 2010). Singapore introduced the world's first road-charging scheme in the 1980s and it is now at the forefront of sustainable policies on waste, water and the greening of the environment (Phang 1993; Suzuki et al. 2010).

1. Satterthwaite (2008) estimates that a quarter of the world's population lives in cities below 500,000 and another quarter in urban areas below 500,000 inhabitants. He suggests that roughly two-thirds of the world's population live in rural areas and small towns. This indirectly suggests that about one-third of the global population might live in cities.

2. The greening of cities requires some, or preferably all, of the following: (1) controlling diseases and their health burden; (2) reducing chemical and physical hazards; (3) developing high quality urban environments for all; (4) minimising transfers of environmental costs to areas outside the city; and (5) ensuring progress towards sustainable consumption (Satterthwaite 1997). This chapter cuts across all five areas, but the issue of cities in relation to climate change – given its primacy in international environmental policy – is given added weight.

3. Ecological footprint measures how much biologically productive land and water area a human population or activity requires to produce the resource it consumes and to absorb its wastes, using prevailing technology and resource management practices. These areas are scaled according to their biological productivity to provide a comparable unit, the so-called global hectare.

4. While many of these initiatives have made major strides in reducing carbon emissions, it is important to note that none of these cities possesses an ecological footprint below 4 hectares per capita (UN-HABITAT 2008; own calculation by Arup) – more than twice the world average biocapacity per capita in 2006 – suggesting that there is still some way to go in implementing sustainable change.

2 Challenges and opportunities

Urbanisation brings both challenges and opportunities for green cities. Challenges include the rapid pace of urbanisation and related pressure on the environment and social relations if it continues on the same trajectory (the business-as-usual or BAU model). Opportunities for green cities include the possibility to design, plan and manage their physical structure in ways that are environmentally advantageous, advance technological innovation as well as profit from synergies that exist between the constituent elements of complex urban systems.

2.1 Challenges

The rapid pace of urbanisation

In 2007, for the first time in human history, 50 per cent of the global population lived in urban areas. Only a century ago, this figure stood at 13 per cent but it is now predicted to reach 69 per cent by 2050 (UN Population Division 2006 and 2010). In some regions, cities are expanding rapidly, while in others, rural areas are becoming more urban. A significant part of this urbanisation is taking place in developing countries as a result of natural growth within cities and large numbers of rural-urban migrants in search of jobs and opportunities. Often this happens despite widespread anti-urbanisation policies, which aim to balance development and to sustain rural economies (UNFPA 2007). However, such efforts have mostly been unsuccessful and risk that urban agglomerations are left unprepared for inevitable increase in population growth. Rapid urban growth tends to overwhelm cities where the struggle to develop infrastructure, mobilise and manage resources has negative consequences for the environment.

The scale of the problem comes into sharp focus in India and China. India's urban population grew from 290 million in 2001 to 340 million in 2008 and it is projected to reach 590 million by 2030 (McKinsey Global Institute 2010). The country will have to build 700-900 million square metres of residential and commercial space a year to accommodate this growth, requiring an investment of US$ 1.2 trillion to build 350-400 kilometres of subway and up to 25,000 kilometres of new roads per year. Similarly, China's urban population is expected to increase from 636 million in 2010 to 905 million by 2030 (UN Population Division 2010). It is predicted that by 2050 the country will need to invest 800-900 billion RMB per year to improve its urban infrastructure, about one-tenth of China's total GDP in 2001 (Chen et al. 2008). The nature of this investment will have significant effects on the potential of Indian and Chinese cities to be green.

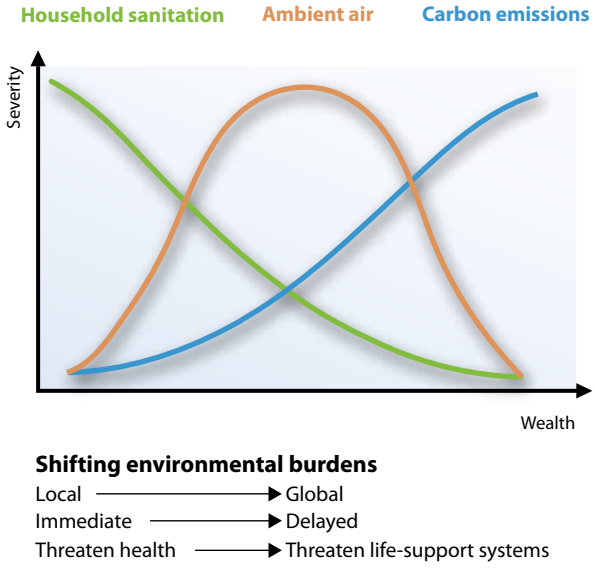

Figure 1: Urban environmental transition
Source: McGranahan et al. (2001)

Urbanisation and the environment

Cities of different wealth levels impact the environment differently. Local environmental threats are most severe in poorer cities and relate to issues such as fresh water, sewage, health and the degradation of the living environment. As cities become more prosperous, with wider and deeper patterns of consumption and production, their environmental impacts are increasingly felt at the global level (Figure 1: Urban environmental transition).

Urban areas in prosperous economies concentrate wealth creation as well as resource consumption and CO_2 emissions. Globally, with a population share of just above 50 per cent but occupying less than 2 per cent of the earth's surface, urban areas concentrate 80 per cent of economic output, between 60 and 80 per cent of energy consumption, and approximately 75 per cent of CO_2 emissions (Kamal-Chaoui and Robert 2009; UN Population Division 2010). This pattern is not equally distributed across the globe and reflects the concentration of particular activities within individual cities. Buildings, transport, and industry – which are constituent components of cities and urban areas – contribute 25, 22, and 22 per cent, respectively, of global energy-related GHG emissions (Herzog 2009). Between 1950 and 2005, the urban population grew from 29 per cent to 49 per cent of the global population (UN Population Division – World

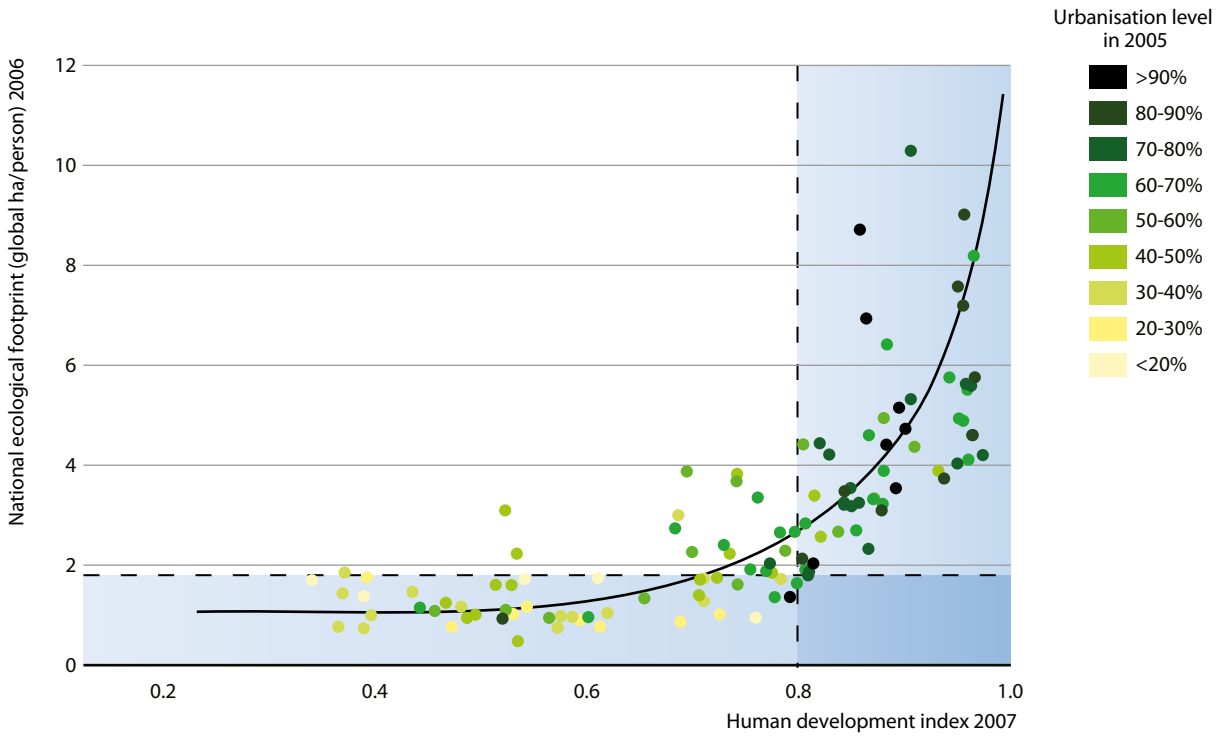

Figure 2: Ecological Footprint, HDI and urbanisation level by country
Source: LSE Cities based on multiple sources

Urbanisation Prospects 2007), while global carbon emissions from fossil-fuel burning increased by almost 500 per cent (Boden et al. 2010).

At the national level, urbanisation goes hand in hand with increasing resource consumption, more energy intensive food supply, and ever-increasing flows of goods and people. This general trend is illustrated in Figure 2: Ecological Footprint, HDI and urbanisation level by country, which compares the National Ecological Footprint with the Human Development Index (HDI) for countries worldwide, including their urbanisation levels. The graph shows that countries with higher urbanisation levels tend to have a significantly greater ecological footprint per capita, suggesting that cities may be bad for the environment. But, the story is more complex.

Brazil, for example, maintained relatively low per capita carbon emissions despite its growing urbanisation (World Bank 2009). Other nations also raised their carbon emissions with no or little increase in urbanisation (Satterthwaite 2009).[5] Cities *per se* are neither drivers of climate change nor the source of ecosystem degradation; certain consumption and production patterns as well as certain population groups within cities are.

The relationship between carbon emissions and income levels is not straightforward, either, as shown in Figure 3: Carbon emission and income for selected countries and cities. Carbon emissions are directly related to income. Per capita incomes are generally higher in cities than in rural areas, generating higher average per capita demand in major emissions sources. But this is the case only up to a certain income level, after which cities typically become more carbon-efficient compared with the average, as can be seen by the relatively low levels of CO_2 emissions produced by high income cities like Tokyo or Paris.

A recent survey of the energy intensity (a measure of the energy efficiency of an economy calculated as units of energy per unit of GDP) of fifty cities by the World Bank confirms differential patterns of environmental performance. From this study, it appears that the combined energy intensity of major cities like Paris, Dhaka, São Paulo, London, Hong Kong, and Tokyo, amount to about one-quarter of that of the five highest-scoring cities and less than half of a fifty-city average (World Bank 2010).

In order to better understand these variations, data on 735 cities in six regions were analysed. The results show

5. It is important to note, however, that the term urban in most countries includes any form of settlement with relatively low number of residents (thresholds typically range from anything between 200 and 20,000), and therefore does not capture the way which cities of a significant size perform in relation to these parameters.

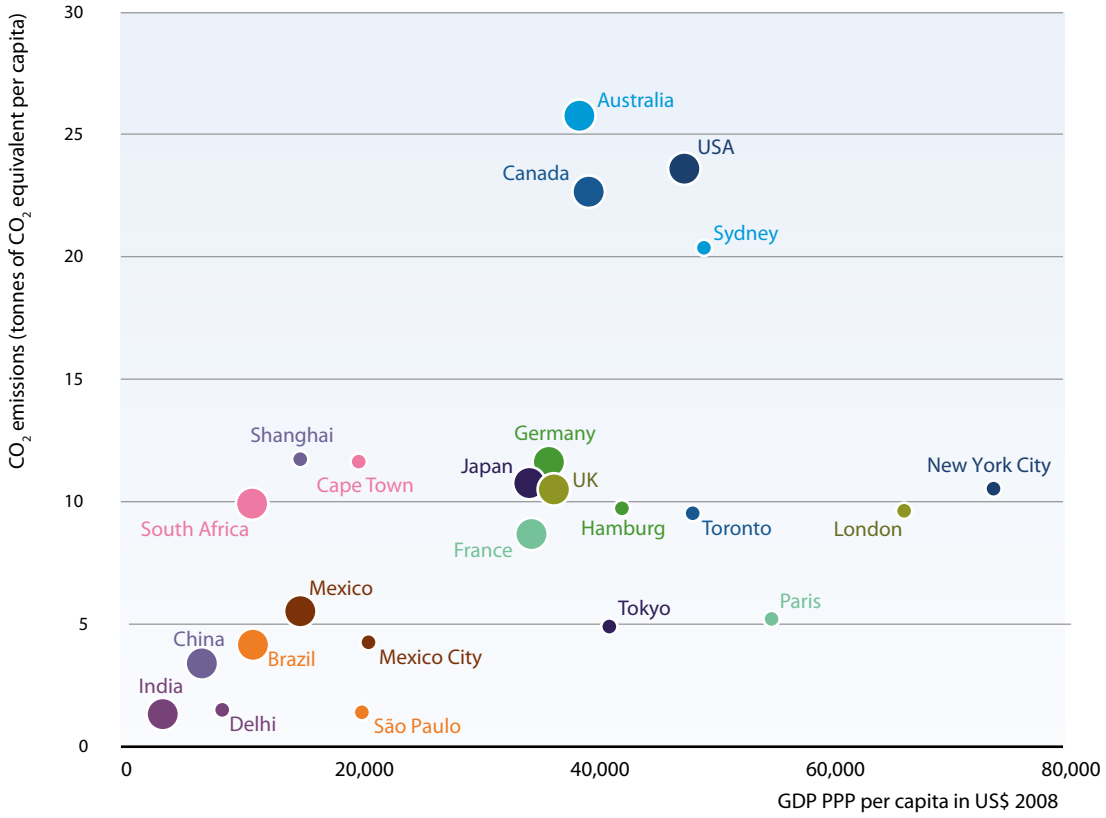

Figure 3: Carbon emission and income for selected countries and cities
Source: LSE Cities based on multiple sources, see Appendix 1

that a majority of cities in Brazil, China, South Africa, India, Europe and the United States cities outperform their national average in terms of income per capita, education and employment levels. In terms of carbon emissions, energy, electricity and water consumption, dwelling and transport patterns and motorisation, however, there is a very marked difference between cities in developed and developing countries. Whereas cities in Europe, the USA and Brazil have a lower environmental impact than their respective countries, cities in India and China have a much larger impact owing to their significantly higher income levels compared with their national averages.

The social implications of traditional urban development

Patterns of urbanisation in many areas also raise important social challenges. The traditional business as-usual (BAU) model of urban development – typical of rapidly urbanising areas – is characterized by uncontrolled, often even incentivised, horizontal expansion. This leads to urban sprawl of affluent populations with lower development densities and increased dependency on the private car and to peripheralisation of the urban poor, decreasing their access to the city and its workplaces, services and infrastructure. Typical developments further include the emergence of socially divisive neighbourhoods in the form of gated communities, shopping centres and business districts and, a significant increase in the level of informal development with large swathes of slum housing with no access to basic services, infrastructure and sanitation. At a general level, the rapid growth of many cities coupled with insufficient resources and poor management compromises fresh water and electricity supply, waste treatment, transport, and other infrastructure provision, affecting the urban poor most.

2.2 Opportunities

Structural capacity

The environmental performance of cities is dependent on a combination of effective green strategies and physical structure – urban form, size, density and configuration. They can be designed, planned and managed to limit resource consumption and carbon emissions. Or, they can be allowed to become voracious, land-hungry, all-consuming systems that ultimately damage the delicate global energy equation.

More compact urban forms, reduced travel distances and investment in green transport modes lead to greater energy efficiency. Lower surface-to-volume ratios of denser building typologies can result in lower heating and cooling loads. Greater utilisation of energy efficient utilities can contribute to lower embedded energy

demand for urban infrastructure. Cities can be structured to make use of green grid-based energy systems such as combined heat and power and micro-generation of energy as well as rainwater harvesting, access to clean water and efficient waste management. In short, effective urban planning and governance, as will be shown below, can have significant effects on sustainable urban lifestyles, making the most of urban critical mass and reducing individual patterns of consumption.

Despite a rich debate on the links between physical structure and energy use in cities, there is growing evidence that compact urban environments, with higher-density residential and commercial buildings (as opposed to low density, sprawl-like development) and a well distributed pattern of uses and an efficient, transport system based on public transport, walking and cycling reduce the energy footprint (Newman and Kenworthy 1989; Owens 1992; Ecotec 1993; Burgess 2000; Bertaud 2004). Research has shown that the so-called "compact city" model (Jenks et al. 1996) has lower per-capita carbon emissions as long as good public transport is provided at the metropolitan level (Hoornweg et al. 2011).

This relationship between urban form and energy performance also applies at the local, neighbourhood level. In Toronto, for example, a recent study found that car use and building-related emissions jumped from 3.1 tonnes of CO_2 per capita in some inner-city areas to 13.1 tonnes in low-density suburbs located on the edges of the city (Van de Weghe and Kennedy 2007). While the evidence does not identify an ideal size or configuration for green cities, it suggests that highly concentrated urban systems produce public transport efficiencies, and that medium-sized cities tend to perform better than very large or very small cities when it comes to public transport and energy-related efficiency (Ecotec 1993; Bertaud 2004).

Many cities around the world have recognised such structural opportunities for green cities. Copenhagen, Oslo, Amsterdam, Madrid and Stockholm (EIU 2009), together with Curitiba, Vancouver and Portland in the Americas, have all prioritised compact urban development, creating walkable urban neighbourhoods supported by accessible public transport systems. Mumbai, Hong Kong and New York are high density cities where housing, commercial, retail and leisure are in close proximity, thus limiting the length of everyday trips (from home to work). In addition, they possess efficient and extensive public transport networks. In Mumbai, these patterns are related to high levels of poverty and overcrowding, while in Hong Kong and New York they combine considerable levels of energy efficiency with high living standards.

Clearly, there is an upper limit for urban densities to deliver environmental benefits without creating adverse social outcomes due to overcrowding and strained social infrastructure such as health or educational facilities. But if appropriately designed, cities can accommodate relatively high threshold densities even in low-income scenarios (and not just in highly serviced upper income environments). In their study on high density, low income housing in Karachi, Hasan, Sadiq and Ahmed (2010) concluded that net residential densities of up to 3,000 persons per hectare can be reached without compromising environmental or social conditions.

Technological potential

Cities are incubators of innovation due to the close interaction of their residents and workers who benefit from the exchange of ideas and opportunities. In particular, they benefit from the concentration of diverse yet specialised skill-sets in research institutions, firms and service providers that can pilot and scale new technologies in an already highly networked environment. The OECD calculates, for example, that there are ten times more renewable technologies patents in urban than rural areas and that 73 per cent of OECD patents in renewable energy come from urban regions (Kamal-Chaoui and Robert 2009). The fast-growing cleantech clusters in Silicon Valley and the North East of England are both examples of "nursery cities", fostering innovative activity (Duranton and Puga 2001). Silicon Valley business leaders have been working for years to leverage the valley's innovation advantage in a green economy (Joint Venture Silicon Valley Network 2009). Section 4 illustrates how urban systems can be readily adapted to innovative technologies that support the transition to green cities, especially in the energy sector.

Urban synergy and integration potential

Green cities can benefit greatly from synergies between their constituent parts. Recognising, for example, the interrelationship of energy systems and city fabric can lead to particular synergies, as pioneered by the Rotterdam Energy Approach and Planning (Tillie et al. 2009). In New York City, a new mechanism introduced by the Mayor combines the cleaning-up of light-to-moderately contaminated brown-field sites with urban re-development (City of New York 2010). Water-sensitive urban design, which helps to retain storm water in public spaces and parks, has increased the reliability of urban water supply in US and Australian cities (see Water Chapter).

An urban setting, which tends to support a diverse and compact pattern of production and consumption is further advantageous to advance the notion of "industrial ecology" (Lowe and Evans 1995). By optimising and synergising different industrial sectors and resource flows, outputs of one sector that become the input of

another create a circular economy (McDonough and Braungart 2002). Principles of symbioses can also help minimise or recycle waste. São Paulo's Bandeirantes landfill, for example, is sufficiently large to provide biogas that generates electricity for an entire city district (ICLEI Local Governments for Sustainability 2009a).

These opportunities have led to intensified efforts in designing cross-sectoral green city strategies when developing new districts or eco-cities. Recent examples of new green communities include the car-free neighbourhood of Vauban in Freiburg and Beddington Zero Energy Development (BedZED)[6] in London (Beatley 2004; Wheeler and Beatley 2004; C40 Cities 2010a). In the latter case, new homes achieved an 84 per cent reduction in energy consumption and footprints related to mobility decreased by 36 per cent. Recycling reduced waste by between 17 per cent and 42 per cent (Barrett et al. 2006).[7] Examples of green city districts include Amsterdam-Ijburg, Copenhagen-Orestad and Hammerby Sjostad in Stockholm while eco-cities have become fashionable in several rapidly urbanising Asian countries. In recent years, high profile investments have been made in sustainable new towns, including Tianjin Eco-City in North China, the Songdo Eco-City in Incheon, Republic of Korea and Masdar Eco-City in Abu Dhabi, but it is early days to make a comprehensive assessment of their long-term sustainability, especially given the very high capital and development costs of these show-case projects.

6. The footprint of BedZED residents averages 4.67 global hectares (BioRegional 2009). While this is lower than the UK average of 4.89 hectares (Ewing et al. 2010) it is still more than twice the "fair share" of 2 hectares. This demonstrates the limitations of insular approaches. While BedZED enables residents to reduce their footprint on site, a lot of their ecological impact is made outside of it, in schools, at work, and on holiday. BedZED residents fly slightly more frequently than the local average, presumably due to their higher average income. These limitations, however, do not invalidate the achievements of the development, but point to the need of scaling up energy efficiency measures in wider urban settlement systems as well as the issue of energy still being comparatively cheap in high-income societies, resulting in overall unsustainable levels of energy consumption, with rebound effects partly offsetting efficiency gains due to greater overall consumption levels (Binswanger 2001) .

7. In recent years, the French government has increasingly become attached to the concept of éco-quartiers and has initiated a range of projects including Quartier ZAC de Bonne in Grenoble, Quartier Lyon Confluence and Quartier du Théâtre in Narbonne (French Government, Ministère de l'écologie, du développement durable, des transports et du logement 2010).

3 The case for greening cities

The case for greening cities can be made in terms of inter-linked economic, social, and environmental benefits. Economically, the benefits include agglomeration economies, lower infrastructure costs and reduced congestion cost while reducing carbon emissions and other environmental pressure. Socially, the benefits include employment creation, poverty reduction and improved equity, and quality of life including improved road safety and community cohesion, among others. Environmental benefits are embedded in most of the economic and social benefits. Additional environmental benefits include reduced pollution, which helps improve public health. Another environmental benefit is the potential for improving ecosystems within urban areas.

3.1 Economic benefits

Agglomeration economies

Larger, denser cities – which help lower per capita emissions – are good for economic growth. From an economic perspective, cities matter because they bring people and things closer together, help overcome information gaps, and enable idea flows (Glaeser 2008; Krugman 1991). It is for these reasons that 150 of the world's most significant metropolitan economies produce 46 per cent of global GDP with only 12 per cent of the global population (Berube, Rode et al. 2010). These agglomeration economies translate into productivity gains for firms, and higher wages and employment rates for workers. For many firms and workers, particularly those in service sectors, there is still a premium on face-to-face contact – to maintain trust, build relationships, and manage interactions that can not yet (and may never) be digitised (Charlot and Duranton 2004; Sassen 2006; Storper and Venables 2004). Knowledge spillovers between firms and economic agents tend to be highly localised and die away within a few miles of the urban core (Rosenthal and Strange 2003).

Agglomeration economies exist in both developed and developing countries. Empirical studies in developed countries find that doubling the employment density of an urban area typically raises its labour productivity by around 6 per cent (for a summary of the literature see Melo et al. 2009). The same basic patterns are found in developing countries, with strong evidence that urbanisation boosts productive efficiency by lowering transport costs and widening trade networks (Duranton 2008; Han 2009). Agglomeration economies can also be achieved by connecting several cities as in China's Pearl River Delta region (Rigg et al. 2009), with the additional benefit of addressing inequality between leading and lagging regions within countries (Ghani 2010).

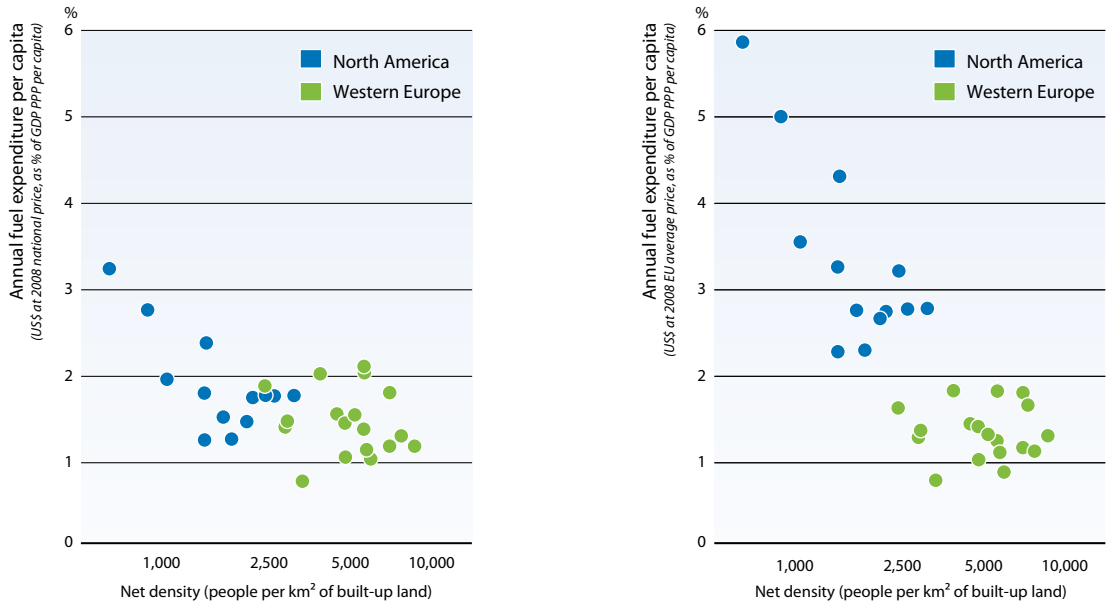

Figure 4: Private transport fuel expenditure and urban density of selected cities, 2008 fuel prices (left-hand graph) and EU fuel prices throughout (right-hand graph)

Source: Kenworthy 2003 (1995/6 fuel consumption and density per city), GTZ 2009 (National 2008 fuel prices), PWC 2009 and UN 2010 (City GDP PPP per capita); see Appendix 1

	Total cost (CA$ billion)			
	Dispersed scenario	Recommended direction	Difference	Percent difference
Road capital cost	17.6	11.2	6.4	-36
Transit capital	6.8	6.2	0.6	-9
Water and wastewater	5.5	2.5	3.0	-54
Fire stations	0.5	0.3	0.2	-46
Recreation centres	1.1	0.9	0.2	-19
Schools	3.0	2.2	0.9	-27
Total	34.5	23.3	11.2	-33

Table 1: Infrastructure costs for different development scenarios in Calgary
Dispersed scenario: additional 46,000 ha; recommended direction: additional 21,000 ha
Source: IBI Group (2009)

In developing countries, however, urbanisation may not provide the same kind of economic gains across cities and firms. For example, Brülhart and Sbergami (2009) find that within-country agglomeration boosts GDP growth only up to national income levels of US$ 10,000 per head. The main reason for this is that very rapid – and sometimes chaotic – urbanisation can outstrip national and city governments' ability to provide adequate infrastructure and services (Cohen 2006). Congestion could eat up the benefits of higher density as in the case of cities like Shanghai, Bangkok, Manila and Mumbai (Rigg et al. 2009). Venables (2005) similarly suggests that "the presence of increasing returns to scale in [some developing country] cities leads to urban structures that are not optimally sized".

Lower infrastructure and operating costs

Densification reduces the capital and operating costs of infrastructure. Evidence suggests that linear infrastructure including streets, railways, water and sewage systems as well as other utilities come at considerably lower cost per unit the higher the urban density (Carruthers and Ulfarsson 2003). Comparing smart growth areas and dispersed, car-dependent developments, Todd Litman suggests direct cost savings between US$ 5,000 and US$ 75,000 for building road and utility infrastructure per household unit (Litman 2009a). A recent exercise for Calgary (IBI Group 2009) indicates cost savings beyond pure linear infrastructure but also for schools, fire stations and recreation centres (see Table 1). Similarly, a recent study of Tianjin concluded that infrastructure cost savings as a result of compact and densely clustered urban development reach 55 per cent compared with a dispersed scenario (Webster et al. 2010).

Figure 4: Private transport fuel expenditure and urban density of selected cities shows how urban density can be an essential measure for decreasing long-term operating costs. Critically, this relationship is made even stronger in the right-hand graph which standardises 2008 fuel prices at the EU average (US$ 1.41) – in other words, it assumes that all cities in the sample face the same fuel price. It is clear that EU cities tend to be denser than North American cities and significantly more effcient in terms of fuel consumption – citizens of more sprawling North American cities tend to travel further. But even with current US fuel prices, density pays back. In the case of New York City, CEO for Cities (2010) estimates that density-related cost savings through reduced expenditure on cars and petrol translates into a green dividend of US$ 19 billion annually.

While denser city strategies tend to promote greater energy efficiency and cheaper infrastructure, promoting transport modal shifts can deliver higher lifecycle capacity and lower running costs (see Table 2: Capacity and infrastructure costs of different transport systems). The most significant cost saving is derived from a shift away from car infrastructure towards public transport, walking and cycling. For example, at similar capacity levels, bus rapid transit (BRT) offers significant costs savings compared to traditional metro

Transport Infrastructure	Capacity [pers/h/d]	Capital costs [US$/km]	Capital costs/ capacity
Dual-lane highway	2,000	10m – 20m	5,000 – 10,000
Urban street (car use only)	800	2m – 5m	2,500 – 7,000
Bike path (2m)	3,500	100,000	30
Pedestrian walkway / pavement (2m)	4,500	100,000	20
Commuter Rail	20,000 – 40,000	40m – 80m	2,000
Metro Rail	20,000 – 70,000	40m – 350m	2,000 – 5,000
Light Rail	10,000 – 30,000	10m – 25m	800 – 1,000
Bus Rapid Transit	5,000 – 40,000	1m – 10m	200 – 250
Bus Lane	10,000	1m – 5m	300 – 500

Table 2: Capacity and infrastructure costs of different transport systems
Source: Rode and Gipp (2001), VTPI (2009), Wright (2002), Brilon (1994)

and regional rail. Bogotá's TransMilenio infrastructure cost US$ 5.8 million per km, US$ 0.34 per passenger over three years compared with estimates for metro rail with US$ 101 million per km, US$ 2.36 per passenger (Menckhoff 2005). As a result and unlike most public transport systems, TransMilenio is not only able to cover its costs but is making a profit (Whitelegg and Haq 2003).

A preliminary study has been carried out to provide additional information on the costs and potential savings of green city projects (Table 3: Investment and operating costs of selected green city projects). Column 3 in Table 3 contains either the project operating revenue (such as the fares collected or the sale of the collected energy) or the savings the project allowed. The savings have been calculated by looking at the difference between what would have been spent in resources without the project and what has been spent since its realisation. For example, Tokyo's water leakage control leads to savings both in terms of electricity (less of which is needed for the same amount of water reaching end-consumers) and in terms of water.

Reduced congestion costs

Bigger, more productive cities tend to suffer from crowding and congestion, as firms and households compete for space in the most popular locations (Overman and Rice 2008). Real-world examples of urban agglomerations such as Mexico City, Bangkok and Lagos suggest that the economic advantages of being in cities tend to mitigate even severe congestion problems (Diamond 2005). Even so, however, the financial and welfare costs to cities and citizens can be substantial. In the largely urbanised European Union, these costs are 0.75 per cent of GDP (World Bank 2002). In the case of the UK, they amount to an annual costs of up to £ 20bn (Confederation of British Industry 2003). They reach even higher figures in developing countries. The costs of congestion in Buenos Aires are 3.4 per cent of GDP, in Mexico City 2.6 and in Dakar 3.4 per cent (World Bank 2002).

One proven method for controlling congestion is demand management via charging. For example, Central London's congestion charge reduced congestion by 30 per cent from February 2003 to February 2004 compared with previous years (Transport for London 2004a) and led to benefits such as the reduction in the number of trips by private vehicles entering central London (Transport for London 2004b) and a 19.5 per cent drop in CO_2 emissions (Beevers and Carslaw 2005). Stockholm's congestion tax also resulted in a reduction in traffic delays by one-third and a decrease in traffic demand by 22 per cent (Baradaran and Firth 2008). The annual social surplus of Stockholm's congestion tax is estimated to be in the region of US$ 90 million (Eliasson 2008).

Many public transport projects around the world have brought about significantly reduced congestion costs, notably BRT systems such as in Bogotá and successfully emulated in Lagos, Ahmadabad and Guangzhou and Johannesburg. A synergetic interplay of compact urban form and an efficient bus system has been observed in Curitiba, which boasts the highest rate of public transport use in Brazil (45 per cent). There, reduced congestion means much less fuel is wasted in traffic jams: only US$ 930,000, compared with an estimated US$ 13.4 million in Rio de Janeiro (Suzuki et al. 2010).

3.2 Social benefits

Job creation

Greening the cities can create jobs on a number of fronts: 1) urban and peri-urban green agriculture; 2) public transport; 3) renewable energy; 4) waste management and recycling; and 5) green construction. Green services will generally be more urban-orientated than green manufacturing or primary industry, although there will be some high-tech green manufacturing clusters in or close to urban cores, drawing on knowledge spillovers from universities and research labs. Already, the 100 largest metropolitan regions in the USA have far greater shares of low-carbon employment in wind and solar energy (both 67 per cent), energy research (80 per cent) and green buildings (85 per cent) compared with the 66 per cent share of the national population (Brookings and Battelle 2011).

At the same time, specific sectors and firms may combine remote or off-shored production with highly urbanised consumer/service/support markets. This means that there is potential for cities to grow both green tradable activity (high value, exportable) and develop greener non-tradable activities (lower value, goods and services for local consumption) (Chapple 2008). Overall, a green economy cannot be expected to create or destroy net jobs in the long run; the supply and demand for labour tend to equate in accordance with labour market conditions. In a well-functioning labour market, in the long run, increased demand for labour in one sector will put upward pressure on the going wage rate and displace labour in another sector. Labour creation in low-carbon sectors will crowd out labour creation elsewhere. Hence, although gross employment in the sector may rise in the long run, net employment across all sectors may not. In the short run, with unemployed resources, the net employment creation effect is likely to be larger.

First, there is considerable policy interest in urban and peri-urban agriculture (Smit and Nasr 1992; Baumgartner and Belevi 2001). Green urban agriculture can reuse municipal wastewater and solid waste, reduce transportation costs, preserve biodiversity and

Project	Initial capital costs (million US$)	Operating costs (million US$)	Operating revenue / savings (million US$)
London Congestion Charge (2002-2010)	480	692	1,746
Bogotá Transmilenio (2000-2010)	1,970 (until 2016)	around 20/year	around 18.5/year
Copenhagen District Heating (1984-2010)	525	136.5	184
Paris Velib' (2007-2010)	96 (private investment)	4.1 (private)	3.96/year (city), 72/year (private)
Bogotá CicloRutas (1999-2006)	50.25	-	40/year (fuel savings)
Toronto Atmospheric Fund (1991-2010)	19	-	2.2
Austin Energy's GreenChoice Program	-	-	3.9 (customer energy savings in 2006)
Austing Green Building Programme (1991-2010)	-	1.2/year	2.2/year (customer energy savings)
Freiburg PV system (1986-2010)	58.6	-	-
Berlin's Energy Saving Partnership (1997-2010)	-	-	12.2 (energy bills)
Toronto Lake Water Conditioning (2002-2010)	170.4	-	9.8/year
Tokyo Water System	-	60.3/year	16.7 (electricity savings), 172.4 (leakage prevented)
San Francisco Solar Power system (2004-2010)	8	-	0.6
São Paulo waste to energy (2004-2010)	68.4	-	32.1 (from carbon credit auction)
Curitiba BRT (1980-2010)	-	182.5	201
Stockholm Congestion Charge (2007-2010)	350	-	70
NYC public plaza improvements (2008-2010)	125.8	-	-
Strasburg's 53.7 km tram (1994-2010)	-	167.7	168.3
Copenhagen's 3% of waste to landfills (1990-2010)	-	-	0.67/year
Copenhagen offshore 160MW windfarm (2002-2010)	349	-	-
NYC Greener, Greater Buildings Plan (2009-2010)	80 (city), 16 (federal)	-	700/year (residential energy costs)
Hong Kong Combined Heat and Power plant (2006-2010)	0.9	-	0.3/year
Portland SmartTrips (2003-2010)	-	0.55/year	-
Portland LED traffic lighting (2001-2010)	2.2	-	0.335
Seoul car-free days (2003-2010)	3	-	50/year (fuel savings)

Table 3: Investment and operating costs of selected green city projects
Source: multiple sources, see Appendix 1

wetlands, and make productive use of green belts. The findings of national censuses, household surveys and other research suggest that "up to two-thirds of urban and peri-urban households in developing countries are involved in agriculture" (FAO 2001).

Second, transport activities typically make up a significant share of a city's employment (operationally and in infrastructure development). In many countries, public transport jobs account for between 1 per cent and 2 per cent of total employment (UNEP, ILO, IOE and ITUC 2008). In New York almost 80,000 local jobs are related to its public transport sector, in Mumbai more than 160,000 and in Berlin about 12,000 (Table 4: Urban transport employment).

Third, the International Labour Organisation research (UNEP et al. 2008) indicates that shifting from conventional to renewable energy will result in small net job losses, but cities are well-placed to benefit from new opportunities. As well as research and development activity, renewable energy systems may often involve decentralised production, which locates power generation close to urban consumer cores. Critically, installation and servicing activities are both labour-intensive and urban-orientated. These domestic or personal service activities will be an important source of green jobs in urban areas.

Fourth, waste and recycling activity is similarly labour-intensive. A recent estimate reveals that up to 15 million people are engaged in waste collection for their livelihood in developing countries (Medina 2008). For example, in Dhaka, Bangladesh, a project for generating compost from organic waste helped create 400 new jobs in collection activities and 800 new jobs in the process of composting. Workers collect 700 tonnes/day of organic waste to obtain 50,000 tonnes/year of compost (see Waste Chapter). And in Ouagadougou, Burkina Faso, a project for collecting and recycling plastic waste has helped improve

Box 1: Green jobs in the urban economy[8]

The process of making the world's cities and urban fabric greener and maintaining them in a sustainable way will bring considerable employment opportunities. Upgrading to greener infrastructure generates jobs, whether by improving roads and buildings, establishing public transport networks, repairing and enhancing drainage and sewerage systems or creating and managing efficient recycling services. Many of these jobs will require knowledge of new technologies or working practices, for example, in constructing, installing and maintaining local hydrogen fuel-cell power stations or a network of charging points for electric vehicles. Providing training and support is fundamental to the process, within local authorities and for private companies, particularly small enterprises.

In creating the jobs that will enable cities to be greener, there is a great opportunity to address urban poverty, which is widespread (and in many places increasing at a faster rate than rural poverty), particularly in developing countries. Providing job opportunities where there are few is clearly important, but to make real inroads into poverty, employment must also encompass workers' rights, their social protection and social dialogue. The burgeoning international movement on "the right to the city" promotes community and consumers' rights but workers' rights are increasingly being recognized. Coalitions of urban workers in Brazil, for example, are helping to draw attention to and reduce informal, casualised labour. Inappropriate working and living conditions expose many urban workers to risk on a daily basis, while many do not have access to an adequate system of health care, pay for holidays and protection against loss of pay when they are unable to work. Several ILO initiatives provide a sound basis for action on improving social protection, and other efforts of communities to organise their own risk protection should be supported.

In Marikina, Philippines and through the municipal "decent work" programmes of Belo Horizonte and São Paulo, Brazil, progress has been made in improving labour conditions by establishing meaningful dialogue between workers, employers and local governments. In sum, the greening of cities can and should provide significant opportunities for decent employment, which can bring prosperity and, if carefully managed, reduce inequality and rural-urban differentials.

the environmental situation and has created jobs and income for local people (ILO Online 2007).

Fifth, many developed nations have also started looking at green construction as the largest possible employment provider. Germany's 2006 retrofitting programme created nearly 150,000 additional full-time equivalent jobs in 2006 (UNEP et al. 2008). Retrofitting existing building stocks will provide a massive employment opportunity for many mature cities, since work is undertaken on site (see Buildings Chapter). Higher environmental standards for construction and fittings also create employment potential. The U.S. Department of Labor estimates that new standards for water heating and fluorescent lamps, among other products, could generate 120,000 jobs through to 2020 (UNEP et al. 2008). Most excitingly, green construction has also the potential of making buildings to go from being exclusively consumers of resources to becoming producers – in esources like water, energy, food and materials, or even green space.

City	Persons employed (operations) in public transport sector
New York	78,393
London	24,975
Mumbai	164,043
São Paulo	15,326
Johannesburg	22,276
Tokyo	15,036
Berlin	12,885
Istanbul	9,500

Table 4: Urban transport employment
Source: LSE Cities based on multiple sources, see Appendix 1

Poverty reduction and social equity

The World Development Report (2009) describes increasing economic density – one of the main features of a green city – as "a pathway out of poverty". Along similar lines, Nadvi and Barrientos (2004) assess the impact of clusters or agglomeration effects on poverty in several urban areas of developing countries. It is observed that these clusters are labour-intensive, informal in nature and also employ a lot of women as household-workers. Based on a study of industrial clusters in Kumasi (Ghana),

8. This box was prepared based on contributions from ILO to this chapter.

Lima (Peru), Java (Indonesia), Sinos Valley (Brazil), Torren (Mexico) and Tiruppur (India), it is shown that usually there is a high rate of employment growth among mature clusters drawing the poor from rural areas. Alongside an increase in employment, this study also showed that wage levels in clusters were higher than average regional wage levels but with longer working hours.

While urbanisation has helped to reduce absolute poverty, the number of people classified as urban poor is on the rise (Ravallion et al. 2007). Between 1993 and 2002, there was an addition of 50 million poor in urban areas while the number of rural poor declined by 150 million (Ravallion et al. 2007). Urban growth puts pressure on the quality of the local environment, which disproportionately affects poorer people, such as the lack of adequate access to clean water and sanitation. This results in a huge disease burden that further affects their livelihood options. Moreover, a large proportion of the urban population is in the informal sector with: a) inadequate access to social security, including health insurance; b) homes in informal settlements in disaster-prone areas – both of which make them more vulnerable to crises. With climate change posing its own threat, the urban poor are likely to be more affected as most live in non-durable structures and in more vulnerable locations such as riverbanks and drainage systems. More generally, the poor have little if no means to reduce potential risks and prepare for the consequences of or be insured against natural disasters.

Innovative approaches to urban planning and management can make urbanisation inclusive, pro-poor and responsive to threats posed by environmental degradation and global warming. For example, enhancing public transport use can reduce inequality in access to public services and other amenities, on top of reducing carbon emissions (Litman 2002). It can also play a part in improving poorer neighbourhoods by relieving vehicle congestion (Pucher 2004). Switching to cleaner fuels for cooking, transport and power generation can minimise local pollution and reduce health inequality (Haines et al. 2007). Poor urban households in low-income nations have to spend a large proportion of their income on energy needs including food and cooking fuel (Karekezi and Majoro 2002). Introducing cleaner and more efficient sources of energy offers the potential to both reduce direct expenditure and to lower health costs connected to indoor-air pollution (Bruce et al. 2002). In Brazil, for example, an initiative in the City of Bentim to install solar heaters in housing estates for low income families resulted in 20 per cent savings in energy consumption and up to 57 per cent savings in the energy bill for the average 3 to 4 member family (ICLEI 2010b). [9]

9. The significant reduction in the energy bill can be explained through the fact that low energy consumption is rewarded by tax benefits. The installation of solar heaters helped the families to reach the threshold of < 90khW/month.

Rank 2010	City	Country	QoI index 2010
1	Vienna	Austria	108.6
2	Zurich	Switzerland	108
3	Geneva	Switzerland	107.9
4	Vancouver	Canada	107.4
4	Auckland	New Zealand	107.4
6	Dusseldorf	Germany	107.2
7	Frankfurt	Germany	107
7	Munich	Germany	107
9	Bern	Switzerland	106.5
10	Sydney	Australia	106.3
11	Copenhagen	Denmark	106.2
12	Wellington	New Zealand	105.9
13	Amsterdam	Netherlands	105.7
14	Ottawa	Canada	105.5
15	Brussels	Belgium	105.4
16	Toronto	Canada	105.3
17	Berlin	Germany	105
18	Melbourne	Australia	104.8
19	Luxembourg	Luxembourg	104.6
20	Stockholm	Sweden	104.5

Table 5: Mercer quality of living city ranking 2010
Source: Mercer (2010)

There are other examples of how greening cities can address poverty and equity concerns. Improving sanitation and fresh water supply can reduce persistent poverty and the adverse impacts of water-borne disease (Sanctuary et al. 2005). Retrofitting older buildings in lower-income neighbourhoods can improve energy efficiency and resilience, reducing the vulnerability of poorer communities when energy prices rise (Jenkins 2010). Upgrading infrastructure in slum areas offers both health benefits and fewer adverse impacts on the environment (WHO 2009).

Improvement in quality of life

Community cohesion is one aspect of quality of life and affects individuals, families and social groups at the neighbourhood and district level. Social relationships not only have particularly positive impacts on physical and mental health but also on economic resilience and productivity (Putnam et al. 1993; Putnam 2004). This is especially the case for disadvantaged people, as community cohesion and social inclusion are linked (O'Connor and Sauer 2006; Litman 2006).

Improving the urban environment by measures such as traffic calming and promoting walkability can help

foster a sense of community (Frumkin 2003; Litman 2006). Such changes are often designed to counteract instances of community severance, as identified by Bradbury et al. (2007):

■ *Physical barriers* whereby either spatial structures themselves prohibit interaction or certain activities cause disruption, as in the case of road traffic;

■ *Psychological barriers* that are related to the perception of certain areas determined by traffic noise and pollution or perceived danger; and

■ *Long-term social barriers* where residents change behaviour following initial disruptions and create a more sustained form of being disconnected from certain people and areas close-by. Putnam's research implies that ten minutes avoided in commuting increases time spent on community activities by 10 per cent (Putnam 2000).

Kuo et al. (1998) observed that the more trees and greenery form part of inner-city public spaces, the more these spaces are used by residents. The study also found that, compared with residents living near barren spaces, those closer to greenery enjoy more social activities, have more visitors, know more of their neighbours, and have stronger feelings of belonging. Wells and Evans (2003) found that children with nature near their homes are more resistant to stress; have lower incidence of behavioural disorders, anxiety, and depression; and have a higher measure of self-worth (Grahn et al. 1997; Fjortoft and Sageie 2000). Green space also stimulates social interaction between children (Moore 1986; Bixler et al. 2002).

A further dimension in the quality of life surrounds road safety. Road traffic accidents are the leading cause of death among young people between 15 and 19 years, according to a report published by the WHO in 2007 (Toroyan and Peden 2007; see also Transport Chapter). Road traffic collisions cost an estimated US$ 518 billion globally in material, health and other expenditure. For many low- and middle-income countries, the cost of road crashes represents between 1-1.5 per cent of GNP and in some cases exceeds the total amount the countries receive in international development aid (Peden et al. 2004). Mohan (2002) showed that this is, in fact, underestimated and evaluated that these costs represent 3.2 per cent of India's GDP.

Some of the most effective strategies to improve pedestrian and cyclist safety include dedicated facilities and motorised vehicle speed controls. An average increase in speed of 1 km/h leads to a 5 per cent higher risk of serious or fatal injury (Finch et al. 1994; Taylor et al. 2000). Dedicated lanes for buses, bicycles and pedestrians, especially along arterial roads should also be a priority. Evidence from the Netherlands, Bogotá and Denmark shows that restricting the space available to cars, limiting their speed and providing safe facilities for pedestrians and cyclists result in the adoption of green transport modes.

Other major attributes of green cities are also considered part of the quality of life, such as walkability, access to green spaces, cycling infrastructure and recreational facilities (HM Government, Communities and Local Government 2009). In developing countries, this may partly explain the relationship between green cities and cities with a high quality of life. Among the top 20 "quality of living cities" identified by Mercer in 2009, at least half have particularly strong green credentials (Table 5). The top five includes best-practice green cities such as Vienna, Zurich and Vancouver. In Zurich, the city's focus on public transport has been an important contribution to its favourable ranking in the Mercer survey (Ott 2002). Similarly, the integration of green space and natural elements within the city significantly enhance the quality of living.

At least in developed countries, a city's overall quality of life (or quality of place), may be linked to economic advantages, mainly as a result of greater attractiveness to skilled workers and high paying firms (HM Government, Communities and Local Government 2009; Lee 2005). Evaluation of the largest companies (more than 500 employees) in the European Union suggests that about 10 per cent of these firms consider quality of life as one of the top three attributes determining location decisions (Healey and Baker 1993 in Rogerson 1999). These decisions, it is argued, are increasingly based on so-called city "lifestyle amenities" which attract highly-skilled, mobile workers with their general flexibility in choosing living and working locations (Hasan 2008).

3.3 Environmental and health benefits

Reducing pollution and improving public health

Air pollution in cities remains a major public health burden, particularly in the developing world. In extreme cases such as Dakar, pollution-related health costs are above 5 per cent of GDP, while a range between 2 and 3 per cent is observable for several mega cities in Latin America and Asia (World Bank 2003). In urban areas globally, around 800,000 deaths per year are caused by air pollution (Dora 2007).

Many cities have already taken decisive action and significantly improved the situation. Outside Europe and the USA, cities with PM 10 levels of 20 mg/m^3 have a mortality rate almost 10 per cent lower than those with levels of 150 mg/m^3 (Dora 2007). Urban greenery provides a unique opportunity to improve air quality. In

Chicago, urban trees provided 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 (McPherson et al. 1994).

There is a broader set of public health issues around healthier lifestyles in cities. It is estimated that physical inactivity accounts for 3.3 per cent of all deaths globally and for 19 million disability-adjusted life-years (Bull et al. 2004). Green urban transport is a unique opportunity to link physical activity and emissions reduction by promoting walking and cycling. In Europe, more than 30 per cent of trips made by cars are for distances of less than 3 km and about half still below 5 km, in theory allowing for their replacement by cycle journeys (European Commission 1999).

It is no coincidence that cities with a long tradition of applying land-use planning, public transport strategies and a focus on public green space are among the healthiest cities in the world. Portland was rated number one of the 100 largest USA cities in meeting Healthy People 2000 goals (Geller 2003), Vancouver is first amongst the Canadian cities (Johnson 2009), Copenhagen and Munich rank amongst the top 10 healthiest and safest cities and Melbourne among the healthiest and safest in Australia (Sassen 2009).

Ecosystem services and risk reduction

Urban greenery and vegetation represent a range of ecosystem services with significant wider welfare effects (TEEB 2010). A study of Toronto's Green Belt estimated the value of its ecosystem services at CA$ 2.6 billion annually, an average of around CA$ 3,500 per hectare (Wilson 2008).

Ecosystem services further play a critical role in risk reduction measures. Tropical cities such as Jakarta have dramatically increased their risk exposure to flooding as a consequence of local deforestation. The city's most recent floods in 2007 affected 60 per cent of the city region, killed 80 persons and forced more than 400,000 residents to leave their homes (Steinberg 2007). Similarly, the 2005 floods in Mumbai, which killed more than 1,000 people and paralysed the city for almost five days (Revi 2008) were linked to a lack of environmental protection of the city's Mithi River (Stecko and Barber 2007).

Restoration of urban ecosystems is part of the city greening effort, which can reduce the impact of freak weather conditions. Coastal regions in particular can benefit both in terms of lives and money. Mangrove re-planting in Vietnam, for example, saves US$ 7.3 million annually on dike maintenance while it costs only US$ 1.1 million (International Federation of the Red Cross and Red Crescent Societies 2002). More generally, an increase in the amount of green cover in urban areas not only increases a city's ability to reabsorb CO_2 but also ameliorates the urban heat island effect (McPherson et al. 1994).

Safeguarding natural ecosystems in cities' hinterlands is also important in reducing their exposure to risk. This is of particular relevance to fresh water supply and food security. As they have expanded, many cities have exhausted local fresh water sources and rely on importing water from their wider region. Such requirement to import water is already associated with enormous costs for cities such as Mexico City and São Paulo. In New York City, the protection of its fresh water supply has allowed the city to avoid paying US$ 5 to US$ 7 billion for an additional filtration plant (TEEB 2010).

4 Greening urban sectors

Having illustrated the general economic, social, and environmental benefits of greening cities, this section looks at examples of how the greening of specific sectors – including transport, buildings, energy, water, waste and technology – can be achieved at the city scale. Most of these sectors are addressed more broadly in the respective chapters of this report, and some of the examples below are referenced elsewhere in this chapter to support broader, cross-sectoral strategies to aid the transition to green cities.

4.1 Transport

Most green transport policies that follow the "avoid-shift-improve" paradigm outlined in the Transport Chapter can be found in cities. While "avoiding transport" is mostly covered by structural adjustments to the shape of cities introduced earlier, classic green transport strategies in cities primarily focus on reducing car use or at least slowing its growth. In Central London, for example, the congestion charge reduced daily vehicles trips by 65,000 to 70,000 (Transport for London 2004 b) and CO_2 emissions by 19.5 per cent (Beevers and Carslaw 2005). Singapore's Electronic Road Pricing and Vehicle Quota System slowed increasing car use and motorisation (Goh 2002). Bogotá's BRT system has contributed to a 14 per cent drop in emissions per passenger (Rogat et al. 2009). It is encouraging, therefore, to see that the BRT system has been replicated in Istanbul, Lagos, Ahmadabad, Guangzhou, and Johannesburg.

In Europe, cities are following Zurich's example of investing in a tram system as the backbone of urban transport in preference to an expensive underground system (EcoPlan 2000). Emission standards and car sharing schemes (Schmauss 2009; Nobis 2006) have reduced car dependency while low-emission zones and timed delivery permits have helped reduce congestion and pollution (Geroliminis and Daganzo 2005).

In recent years, some cities have led efforts to electrify road-based transport, even though walking and cycling are still the greenest forms of transport. Copenhagen, Amsterdam, London, and New York are investing in pro-cycling and walking strategies. Cycle-hire schemes have changed attitudes towards cycling in London and Paris. In South America, cities such as Bogotá, Mexico City and Rio de Janeiro have instituted regular car-free days or weekend street closures (Parra et al. 2007).

4.2 Buildings

Tackling the energy demand of existing building stock is a priority for cities, and urban green building strategies also include more efficient use of other resources such as water and materials. As outlined in the Buildings Chapter, three principal green building strategies can be differentiated: design, technology, and behaviour-related. Particularly in a developing world context, passive design solutions to improve environmental performance are by far the most cost-effective approaches. For example, housing projects on the coast in Puerto Princesa City, the Philippines, have been designed to reduce energy demand through increased natural light, improved ventilation, the cooling effect of the roofing material, and strategic planting (ICLEI, UNEP and UN-HABITAT 2009).

Stringent building codes, mandatory energy certificates, tax incentives and loans, have had a measurable impact on energy demand in a number of European and US cities (C40 Cities 2010b). Toronto's revolving energy fund and Austin Energy's Power Saver Program have imposed higher energy efficiency standards for new buildings and are leading to a comprehensive retrofitting programme of existing building stock (C40 Cities 2010c, Austin Energy 2009). Berlin requires a solar-thermal strategy for all new buildings and Freiburg's energy efficient housing standard has reduced average household energy consumption for space heating by up to 80 per cent (von Weizsäcker et al. 2009). As owners of large amounts of public property, municipal authorities are able to set an example by implementing green strategies on their own public building stock with beneficial effects on the development of a local green building market.

4.3 Energy

Cities uniquely concentrate energy demand and rely on energy sources beyond their boundaries. But cities have the potential to either dissipate the distribution of energy or optimise their efficiency by reducing energy consumption and adopting green energy systems including renewable micro-generation, district heating, and combined heat and energy plants (CHP). Rizhao, China has turned itself into a solar-powered city; in its central districts, 99 per cent of households already use solar water heaters (ICLEI, UNEP and UN Habitat 2009). In Freiburg, PV systems, encouraged by Germany's generous feed-in tariff, now supply 1.1 per cent of the

city's electricity demand. A biomass CHP system and wind turbines provide for a further 1.3 per cent and 6 per cent respectively of the city's energy needs (IEA 2009).

Oslo and São Paulo have harnessed power generated by nearby hydro-electric facilities to gain a relatively high share of renewable energy. Wind and tidal power are becoming increasingly important sources of renewable energy for cities, while geothermal heat can also be exploited to provide reliable, secure, low-cost, power. Manila, located on the island of Luzon, receives 7 per cent of its electricity from geothermal sources (ICLEI, UNEP and UN Habitat 2009). A grid-based, decentralised energy system, with district heating systems can provide space and water heating for large urban complexes (like hospitals, schools or universities) or residential neighbourhoods. They can significantly reduce overall energy demand. Their efficiency further improves with combined heat and power energy generation systems. Copenhagen's district heating system, for example, supplies 97 per cent of the City with waste heat (C40 Cities 2010d).

4.4 Vegetation and landscape

While cities are principally made up of buildings and infrastructure, they can contain a significant proportion of open space. Despite sustained growth, cities like Johannesburg, London and Delhi have maintained high levels of green open space (parks, public and private gardens), while others like Cairo, Tokyo or Mexico City have far lower levels of green space. Parks, protected green space and gardens, street trees and landscaping provide vital ecosystem services, acting as green lungs absorbing and filtering air pollution or as acting as filters for waste water (TEEB 2010). They also provide a habitat for wildlife and offer recreational benefits to city dwellers.[10] As noted above, a study of Toronto's Greenbelt identified its wetland and forests as one of its most valuable assets in terms of ecosystem services including carbon storage, habitat, water regulation and filtration, flood control, waste treatment and recreation (Wilson 2008).

In addition, the presence of green landscaped areas helps regulate natural processes, including the mitigation of local temperature extremes: a ten per cent increase in tree cover reduces cooling and heating energy use by between five per cent and ten per cent (McPherson et al. 1994). Vegetation and soft open space also play a role in decreasing stormwater volumes, thus helping cities to manage the consequences of heavy rainfall, and are effective in helping flood protection in coastal cities. New design strategies have pioneered the use of green roofs and facades on buildings, to add to the quantity of natural (as opposed to man-made) surfaces in cities and to reduce cooling energy demand. For example, Itabashi City in Tokyo is promoting climbing plants as "green curtains" around public buildings and private homes to avoid buildings overheating in summer and to reduce the use of air conditioning (ICLEI 2009b).

4.5 Water

Cities require significant transfers of water from rural to urban areas with water leakage being a major concern. Upgrading and replacement of pipes has contributed to net savings of 20 per cent of potable water in many industrialised cities. Over the last ten years alone, Tokyo's new water system has reduced water waste by 50 per cent (C40 Cities 2010e). Volumetric charging has proven most effective in incentivising more efficient water use. Many cities are introducing water meters and are shifting away from simple water access fees. A measure to maximise utility of fresh water is the cascading of water use where the waste water generated by one process can be used in another with a lesser quality requirement (Agudelo et al. 2009).

To further reduce water consumption and provide alternatives to piped water supply, rain can be harvested and used as drinking and non-drinking water. Such services can only be implemented in cities where there is a greater willingness to pay for water than in rural areas (see Water Chapter). To counter severe water shortages in Delhi, the Municipal Corporation made rainwater harvesting a requirement for all buildings with a roof area above 100 square metres and a plot area greater than 1,000 square metres. It is estimated that 76,500 million litres of water per year will be made available for groundwater recharge (ICLEI, UNEP and UN-HABITAT 2009). In Chennai, urban groundwater recharging raised the city's groundwater levels by four metres between 1988 and 2002 (Sakthivadivel 2007). Fiscal incentives have proved successful, notably Austin's tax rebates for harvesting systems saving an estimated 8.7 gallons per person per day for a single family rainwater harvesting unit (Texas Water Development Board and GDS Associates 2002).

4.6 Food

The food footprint of a city has significant impacts on its green credentials, especially if one takes into account the energy use generated by transporting food from remote locations to urban marketplaces (Garnett 1996). For example, the food supply of European

10. At the macro level, strategies for greening the city protect existing green areas from development. Such measures are of particular importance along the city fringe, where urban growth boundaries in cities such as Portland and London restrict development. In Stockholm, thanks to the protection of green areas, almost the entire population lives within 300 meters of parks and green areas (City of Stockholm 2009).

cities accounts for approximately 30 per cent of their total ecological footprint (Steel 2008). More broadly, urbanisation is usually accompanied by a loss of nearby arable land and a rise in demand for processed foods by urban consumers. While there is some way to go to see a substantial reduction in the food footprints of highly consumptive cities such as London and New York, there is evidence that farmers' markets are successfully re-establishing links between inner cities and regional agriculture. Other cities benefit from their location at the heart of rich agricultural landscapes, which reduces the need for long and expensive travel of food products. In Milan, Italy, up to 40 per cent of daily produce is grown within a four-hour radius of travel, reflecting the city's proximity to the agricultural plains of the Po Valley and the Mediterranean Sea.

Approximately 15-20 per cent of the world's food is produced in urban areas, with urban crops and animal products often representing a substantial part of the urban annual food requirement (Armar-Klemesu and Maxwell 2001). The extensive role of food production in cities is a common feature of many developing world cities. Estimates suggest that 35 per cent of households of Nakuru, Kenya were engaged in urban agriculture in 1998 and nearly half of households in Kampala, Uganda in 2003 (Foeken 2006; David 2010). In Accra, Ghana 90 per cent of the city's vegetable supply is produced within the city's boundaries (Annorbah-Sarpei 1998). Successful urban agriculture projects are scattered across some Western cities, albeit usually on a small scale, making use of communal gardens, roof spaces and unused urban spaces. In shrinking cities such as Detroit, urban farms have been established in some of the areas with particularly low development pressures on land (Kaufman and Bailkey 2000).

4.7 Waste

By concentrating people and activities, cities have become centres of the waste economy, which plays a dominant role in a city's ecological footprint. Yet, cities have demonstrated considerable resilience in finding green solutions that reduce overall waste, increase recycling and pioneering new forms of environmentally friendly treatment of unavoidable waste. In developing world cities which typically suffer from insufficient formal waste collection, it is a large workforce of mostly informal recyclers and reclaimers, such as the Zabbaleen in Cairo, who have implemented sophisticated reuse and recycling systems (Bushra 2000 in Aziz 2004). However, these jobs mostly do not match decent work requirements and green waste strategies in these contexts often fail to recognise the potential role of these actors (Medina 2000) and implement expensive, technology-driven recycling models (Wilson et al. 2006).

In many European cities, recycling levels are in the region of 50 per cent, while Copenhagen only sends three per cent of its waste to landfills (C40 Cities 2010f). In 1991, Curitiba established a green exchange programme (*cambio verde*) that incentivises people to exchange recyclable waste for fresh fruits and vegetables acquired by the city from local surpluses (Anschütz 1996). Composting is a further critical component for greening waste. Positive examples range from Dhaka's decentralised composting to San Francisco's municipal food composting programmes (Zurbrügg et al. 2005).

4.8 Infrastructure and digital technology

The assessment of digital technology on greener cities lies outside the scope of this section of the Report, but a growing body of evidence suggests that cities are the natural sites of investment in smart infrastructure to deliver more sustainable environments. Cities provide a critical mass of potential users for a wide range of IT-based services which build upon complex physical infrastructure (such as roads, rail, cabling and distribution systems). The digital infrastructure of the internet and data centres create an intelligent infrastructure that connects people to people, people to city systems and city systems to each other, allowing cities and their residents to respond to changing circumstances by adapting in near real-time and to recognise patterns to help make informed decisions.

In addition, smart transport systems are being used to tackle congestion, facilitate road user charges or supply real-time information on traffic problems. Examples include Stockholm's congestion tax and Singapore's electronic road pricing. They also facilitate bike hire schemes in many cities around the world. Amsterdam currently trials smart work centres that allow workers to use local office facilities rather than commuting to their main office (Connected Urban Development 2008).

5 Enabling green cities

The previous sections of this chapter confirm that the greening process is complex, fragmented and multi-layered. Enabling green cities *is* and will continue to be equally complex and piecemeal in the near future. There is no single silver bullet that can help shift cities to a green agenda but those that are flexible and diverse will be in a strong position.

This section addresses the key barriers that constrain the adoption of green policies in cities and puts forward a number of practical suggestions on the way forward, based on enabling best practices found in metropolitan regions across the globe. While a "one-size-fits-all" model is neither envisaged nor proposed, it is argued that there are common barriers and constraints in cities in developing and developed countries that need to be overcome before green development can take hold. It further suggests that a combination of political restructuring, policy innovation, market stimulation and consumer participation is essential to enable the gradual transition towards green cities in the coming decades.

Before identifying key constraints, it is important to recognise that the shift to environmental responsibility – in cities, as in all other aspects of the green economy debate – is not just a technical issue, but one that has deep cultural and political ramifications. Hence, governance and democratic accountability, together with a dynamic involvement of the private sector, need to be given equal attention in the discussion about implementation as innovations in policy, planning and regulation. Green city solutions will not be realised overnight by classic top-down or bottom-up approaches, but by the actions of a coalition of actors from the national, state and local levels, from civil society and its multiple subdivisions, from the private sector and institutions including universities, not-for-profit foundations and interest groups who share a commitment to advance the green economy in cities.

5.1 Barriers and constraints

This chapter has argued that there are compelling reasons why the green economy model can be adopted in cities across the world. Section 4 identified examples of best practice in cities across both advanced and developing nations, but they are a drop in the ocean with respect to the vast majority of new urban development in Africa, Asia and the Americas. Today, most cities are adopting fundamentally non-sustainable practices as a result of a combination of the following barriers and constraints, which vary in significance according to geographical location and position with the economic and political development cycle:

- *Fragmented governance* – lack of coordination between policy frameworks that promote green economy measures at supra-national, national, regional and metropolitan levels;

- *Affordability* – even cost-effective green measures may be out of the reach of poorer cities, leaving them saddled with more wasteful urban infrastructure;

- *Lack of investment* – despite wider acceptance of the relevance of the green economy to well-being, the private and public sector have not prioritised green investment in basic city infrastructure (such as green planning, public transport and housing strategies);

- *Negative tradeoffs* – without effective policy intervention and infrastructure investment, (which promote productivity and resource efficiency) green city strategies can lead to greater congestion (of people and traffic), higher land values and costs of living;

- *Consumer preferences* – when given a choice consumers may not be willing to adopt new models of urban living that require changes in individual and collective patterns of consumption (e.g. high-density apartment living, public transport use);

- *Switching costs* – high short-term transition (welfare and capital) costs for businesses that shift from brown to green, leave many companies without adequate compensation to make the investment;

- *Vested business interests* – industry dynamics in construction, road-building and infrastructure are resistant to change that challenges existing business models and threatens the potential of short-term return on investment;

- *Risk aversion* – individuals, corporate and government organisations are resistant to any change that does not demonstrate immediate improvement in economic well-being, quality of life or enhanced status within the community;

- *Perverse policies* – these produce underpriced goods and services, thereby encouraging overconsumption. Such policies include subsidised road infrastructure;

the failure to charge developers fully for the cost of services and infrastructure new developments require; various tax abatements encouraging home ownership and other public policy measures that facilitate urban sprawl and the use of the private car as a dominant means of transport; and

■ *Behavioural response and the rebound effect* – consumers may respond to reduced energy costs (generated by energy efficiency measures) by either increasing per capita energy consumption or by spending savings and increasing overall consumption per head.[11]

5.2 Enabling strategies

Overcoming this set of barriers and constraints requires a multi-faceted response across different sectors, which are addressed in turn, from governance and planning to incentives and financing.

Figure 5: Enabling conditions, institutional strength and democratic maturity illustrates the breadth of policy instruments and tools that can promote investment in greening cities. Importantly, it correlates their effectiveness over time in relation to the strength of local institutions and the strength of the democratic system in different urban contexts. By plotting the enabling conditions available in systems with both strong and weak institutions against weaker and more mature democracies, it suggests that the process of change is in most cases a long one, and requires the development of mature institutions before long-term change can be implemented, whilst recognising that civil-society activism and autonomous green initiatives can be effective in the short-to-medium term, especially in weaker institutions and less mature democracies.

All of these transition factors suggest that it is critical to develop policy frameworks not just at the local and urban level, but also at the regional and national level. More broadly, policy makers need to look at the conditions that will enable cities in different parts of the world to make the transition to green economy models *in relation to* the maturity of their own political infrastructure.

To overcome existing barriers and constraints, joining up is essential. For example, engineering solutions need to be complemented with fiscal instruments such as carbon pricing (Birol and Keppler 2000, in Allan et al. 2006) to harvest the benefits of improved technical efficiencies, while avoiding undesirable rebound effects.

11. see Allan et al. (2006). However, von Weizsäcker et al. (2009) suggest that energy cost savings can provide households with the capital needed to invest in further energy saving measures and the State to invest in R&D in renewable energies, thus even enabling a positive feedback loop.

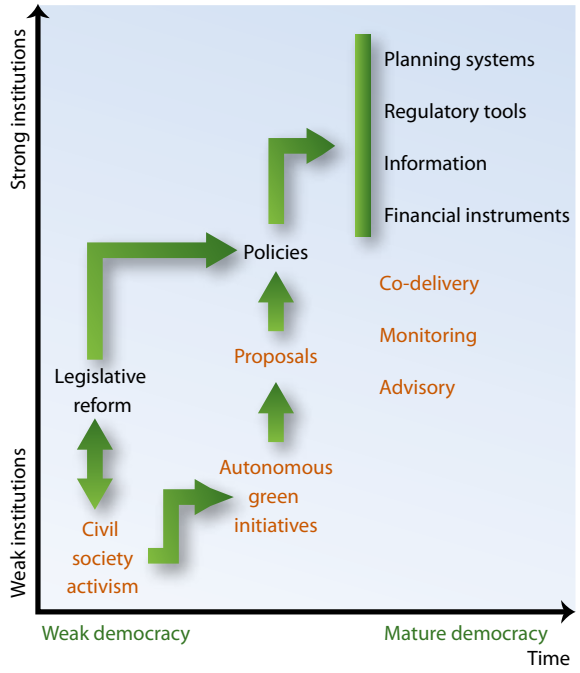

Figure 5: Enabling conditions, institutional strength and democratic maturity

It remains difficult to achieve green city synergies which simultaneously deliver economic prosperity, reduce resource intensity and promote social inclusion because economic added value is derived from processes and regimes that fail to account properly for environmental and social externalities. Until this issue is properly addressed, it is unlikely that fundamental economic enabling conditions to advance green cities will be found.

An efficient global response to the problem of climate change will therefore entail up-front finance and technological support to enable fast-growing cities in the developing world to "leap-frog" developed world cities in planning and installing the latest, most efficient, infrastructure that will bring down resource intensity and save money for decades. But it is to governance that we first turn, to establish the principle for core enabling strategies that can bring about change.

5.3 Governance

Governance encompasses the formal and informal relationships linking the various institutions involved in the urban system – the local, metropolitan, regional, state, civil society and private-sector actors – and its quality depends on the depth of reciprocity, trust, and legitimacy. These are enhanced by mechanisms and opportunities to facilitate meaningful dialogue, and by well-structured organisations in civil society, the business sector and the relevant government level.

The practical imperatives of debating trade-offs and priorities in pursuing green city development can contribute to the maturing of governance relationships.

In contexts with strong local government it is possible to envisage a range of planning, regulatory and financing instruments to advance green infrastructure investments, green economic development and a multitrack approach to greater urban sustainability. In countries where local government is weak or marked by mistrust and disinterest due to its inefficiency and/or corruption, it is important to underscore that unless broad-based cultural movements are fostered that can shift the aspirational horizons of ordinary people, it will prove very difficult to promote and institutionalise the numerous green city reforms proposed in this chapter.

In poorer cities, the building up of such capacities is important, as is their access to financial resources for investing in the various sectors of green cities. Here it may be prudent to adopt a more pragmatic and minimalist approach, which primarily commits municipal sectors such as water, waste, energy and transport to a limited number of strategic goals. These are the major areas where the support from national governments and international organisations is needed.

Coalitions that work to advance green city principles and practices need to identify practical ways in which they can design and execute mass-based campaigns to make alternative approaches to routine consumption a desirable option for ordinary people, especially the middle and working classes but also the large segments of the population that one can term the working poor. In these contexts, it is important to drive home the connections between poverty reduction through effective slum policies, which of course can be dovetailed with aspects of green infrastructure such as decentralised systems and community maintained systems.

However, external (to the local) actors, be they funding agencies or national departments who operate through local offices, are also working on city-wide infrastructure investments and these protagonists should be targeted as well to ensure that they see the potential value of technological leap-frogging and more community-based decentralised delivery systems. But such an ideal immediately sounds naïve because these technological approaches effectively undermine the political control of national elites over local territories. In this sense, advancing effective and deep democratic institutions become a truly foundational enabling condition for green cities.

Effective governance will also come into its own through a substantive agenda or vision that is shared by diverse stakeholders. Such a coalition can promote the idea of a long-term strategic plan for the city complementing the more conventional spatial and environmental planning instruments. For example, the internationally-based Cities Alliance (2007) promotes so-called City Development Strategies (CDS), as appropriate tools to address the nexus between sustainable economic growth and ecological preservation and restoration. They are based on the premise that local governments have little power and funding to promote or impose change, and that partnerships are the only practical way forward.[12]

This should be backed up by effective resource allocation and decision-making systems that demonstrate to everyone in the city that systematic progress is being achieved towards the long-term goal of becoming a green city. To date, however, city level green economy initiatives have been largely decoupled from national policy frameworks. Glaeser and Kahn (2010), in a study of US metro areas, find that the cities with the lowest per capita CO_2 emissions also tend to have the tightest planning restrictions. They suggest that "by restricting new development, the cleanest areas of the country would seem to be pushing new development towards places with higher emissions" (Glaeser and Kahn 2010).

To avoid a patchwork of uncoordinated targets, goals, and programmes, and to allow the most cost-effective emission reduction opportunities to be exploited, national and city initiatives need to be synchronised as part of a coordinated design and implementation of policy instruments. In the example of the USA above, the city-level coordination failure could be dealt with at national level through a personal carbon tax that internalises the environmental costs of household behaviour, including location decisions. Governance restructuring witnessed in many parts of the world often simultaneously involves devolution as well as powers shifting to supranational bodies. These processes increase the role of municipalities as independent policy actors. In addition, they play an important role in implementing national policies at the local level and in shaping the immediate living environment via long standing municipal policy instruments. However, these also need to be improved as decentralisation efforts in most developing countries, and especially in least developed countries remain deeply flawed, uneven and partial (Manor 2004).

Within this framework, it is possible to generalise from everyday practice, and suggest a potential distribution

12. "Local governments alone cannot turn a city around. They control a minuscule portion of the capital available for city building and often have an even smaller proportion of the available talent in urban innovation. Although important as catalysts and as representatives of the public interest (in theory, at least), local governments should work in partnership with private interests and civil society to change a city's developmental direction – CDS processes are based on private, public, and civil society partnerships" (Cities Alliance 2006).

of functions within a three-tier system of governance which could help deliver green city strategies more effectively. In addition, international bodies and bilateral networks can help enabling developing country governments to invest in green cities by providing finance and by helping with technology transfer.

■ The *national/state level* creates the general conditions under which the economy works and for example, has a strong focus on social security; ensuring national policy on water; supplying infrastructure of national importance; and ensuring design standards by implementing general building regulation. In the context of a green economy, national government can set a price on carbon (carbon tax), create markets for clean technologies (carbon pricing, regulation, tax breaks), fund or enable major infrastructure investment (smart grid) and set minimum standards. Besides financing, the national level should also employ preferential policies to enable green cities.

■ The *metropolitan/regional level* includes the entire functional city-region, even though there is often a non-alignment between political boundaries and urban development. Metropolitan governance directly addresses three of the five principle categories of environmental performance (health, hazards and high quality urban environments) with a responsibility for a wide range of functions such as strategic planning, regulating waste disposal and water management, overseeing regional banks and land banks, ensuring skills training matches targets for the regional economy, promoting green transport infrastructure and operations, and setting specific building standards regarding flexible use, additional green targets and climate change adaptation. Increasingly, it is also the metropolitan level that addresses the transfer of environmental costs and sustainable consumption with targets regarding carbon reduction. In these cases, strategic actors such as publicly owned utility companies able to invest long-term or integrated, multi-modal transport agencies facilitating the greening of transport have proved to be extremely beneficial.

■ The *local/municipal borough or district level* operates for areas that might include between 100,000 to 500,000 residents and is responsible for implementing policies developed at other spheres; managing green objectives; implementing food and resource management in close consultation with residents; overseeing local policing; and providing input on socio-economic development for other spheres.

5.4 Planning and regulation

While the large proportion of informal practices makes planning and regulation less relevant in some cities in developing nations, they are the most common policy instruments that shape urban development in more complex and mature political environments. In these instances, they range from strategic and land-use planning to building codes and environmental regulation. Besides regulating for desired environmental outcomes, they help to kick-start green innovation and create demand for green products at various levels.

To maximise synergies across different urban sectors, integrated planning that combines land use and urban development with other policies and cuts across the urban functional region of cities is critical in achieving greater environmental performance. The recently launched World Bank Eco2 Cities programme, for example, demonstrates why planning, finance and infrastructure imperatives are inextricably linked in a low-carbon world (Suzuki et al. 2010). This programme argues for a one-system approach to: "realise the benefits of integration by planning, designing and managing the whole urban system." On a practical level this implies that all cities need to understand their urban form and the nature and patterning of material resource flows through the urban system.

The intersections of infrastructure and the dynamics, resilience or vulnerability of urban form are crucial. As described previously, it is not untypical for poor people to live without access to various infrastructure networks in the most climate-vulnerable areas of a city (Moser and Satterthwaite 2008). Possible impacts on urban form and resource flows need to be considered when planning infrastructure investments, especially given the enormous sums required for capital expenditure in rapidly urbanising areas. More than anything else, urban sustainability will depend upon how these sums are going to be allocated.

A combined understanding of urban form and resource flows helps isolate effective actions to achieve greater overall resource efficiency. It also forces a longer-term horizon for understanding trends, the most strategic intervention points, and how to weigh up trade-offs between various spaces of an urban region. If it is based on sound data, it will hold the potential to provide a shared basis for understanding what is going on in a city, where it may be leading and what needs to be done to change the efficiency of the overall system (Crane, Swilling et al. 2010). It is only when this kind of analysis and political discussion becomes commonplace, that one can achieve a broad-based commitment to effective long-term strategic planning.

The recent UN-Habitat Global Report on Human Settlements seeks to bring planning back to the centre of urban development debates (UN Habitat 2009), reinforcing the idea of strategic spatial planning that focuses on a "directive, long range, spatial plan,

Urban growth boundaries	Establish clear limits to any form of building development around cities to limit urban sprawl; create green corridors that protect existing ecosystems
Land-use regulation	Introduce zoning regulation that prioritises development of inner-city, previously developed (brownfield) land over greenfield development at city-wide level
Density regulation	Provide minimum rather than maximum density standards; establish clear density standards at city-wide level (e.g. Floor Area Ratios, FAR*) in support of compact city development with a hierarchy of higher density, mixed-use clusters around public transport nodes
Density bonus	Provide development bonuses that allow increased development rights (i.e. extra floor area with respect to standard planning regulations) for green projects that support city-wide and local sustainability
Special planning powers	Establish urban development corporations or urban regeneration companies to promote and enable green projects
Vehicle and traffic regulation	Regulate for vehicle types, emission standards, speed limits and road space allocation that favours green transport and especially green public transport
Parking standards	Provide maximum rather than minimum parking standards; reduce private car parking standards to a minimum (e.g. less than one car per household) especially in areas of high public transport accessibility
Car-free developments	Provide planning incentives for car free developments in higher density areas with high public transport accessibility
Minimum emission standards	Regulate minimum carbon emission and energy efficiency standards at the local level for buildings and vehicles

Table 6: Selected planning and regulatory instruments
* FAR is the most common density measure for planning purposes. It is calculated by adding all the area of residential and business floor space and dividing it by the entire area of the development site.

and broad and conceptual spatial ideas" as opposed to traditional master planning with detailed spatial designs. A central component of strategic planning is the linking-up of spatial and infrastructure plans and the promotion of public transport to drive urban compaction and accessibility. Many cities, particularly in Western Europe, have adopted strategic planning while some, including Johannesburg are turning to new planning-regulatory frameworks that serve as a basis for new approaches.

For city governments to insist on planning reform is also crucial for implementing the actions required to address the global environmental crisis. Playing those roles requires a much greater capacity for effectual planning. The planning implied is a clinical engagement with the urban form and flows of the city to identify how best to sequence, coordinate and integrate various infrastructure investments that will set the long-term course for urban efficiency, competitiveness and inclusivity.

The examples cited in previous sections of this chapter suggest that the most effective green city planning strategies have a direct impact on the shape and size of a city and its metropolitan hinterland. Reusing existing urban land while restricting urban sprawl and peripheralisation is central to the creation of sustainable urban environments, especially when retrofitting mature cities with previously developed industrial land. Increasing and maintaining urban density levels is desirable but can only be successful if associated with other services, such as high quality public transport and public space. Urban design and public space standards and a polycentric urban structure that encourages mixed-use developments and varying densities with peaks around nodes supported by public transport are essential. To ensure environmental sustainability, there should be a policy bias against greenfield development in mature or recently established cities, until all available urban land is developed at appropriate densities. While a wide range of planning and regulatory tools exist that can be of particular relevance to the implementation of green cities, Table 6 summarises some of the most effective instruments that have brought about sustainable change in examples reviewed in this chapter.

5.5 Information, awareness and civic engagement

Effective planning and governance across different administrative levels requires high-quality information to raise awareness amongst urban residents to promote behaviour change. In addition, given that cities contain large consumer markets which are potentially valuable to producers of green goods and services, information is also an essential tool to influence consumer choice. But consumer preferences, in developed and developing nations, are not always green. For example, very dense urban development is not always popular in many parts of the UK and Europe (Cheshire 2008) and the North American propensity for suburbanisation is well documented.

At the same time, information and active communication on the potential benefits of greener lifestyles in cities can enable consumers to make more informed decisions. For example, in Munich new residents are given an information package on green mobility opportunities. Using such tools can also impact on the behaviour of businesses as the Indian city of Surat, one of Gujarat's

Monitoring	
Environmental performance measures	Introduce new accounting and benchmarking standards for environmental performance at the city level
Environmental performance targets	Set clear time-based and sector specific targets based on robust indicator for green city development
Carbon budget	Ensure that any urban development strategy or policy across all levels will have to be looked at in terms of carbon emission effects
ecoBUDGET	Introduce this new management system for natural resources and environmental quality measured and accounted for in a budget
City Biodiversity Index	Adopt a city biodiversity index which combines quantifying biodiversity, related ecosystem's services and related management
Geographic Information Systems (GIS)	Integrate this map based analysis tools in all processes allowing cities to better track and plan developments
Engagement	
Online access	Increasing internet access particularly of poorer communities while making all relevant information available online
Public consultation	Issue-based engagement with local communities and public debates with politicians presenting and defending development plans
Local activism	Harness the potential of local activism to improve quality of life and the environment through community-based projects
Transparency	Ensure maximum levels of transparency and advance on freedom of information legislation
E-democracy	Recognise role of e-governance and participation in providing information and access to monitoring and achieving sustainability targets
Awareness	
Education	School curriculums to include "green education" and provision of professional "green training" for public and private organisations
Public campaigns	Raising awareness of the advantages of green city strategies, particularly on compact city living and green transport
Labelling	Eco-labelling of consumer items to help consumers make more informed choices and provide additional incentives for green products
Smart meters	New smart monitoring and metering devices can provide real time information on resource use: Without smart metres no smart consumers
Welcome packs	Providing new residents with information packages on green living as behaviour can be best changed when building a new daily routine
Best Practice	Disseminating information on green city projects that have worked elsewhere to inform local adaptations
Demonstration projects	Establishment of test projects within cities to allow for better assessment and public exposure to new approaches

Table 7: Selected information-based instruments

largest industrial centres, has shown. A combination of information and regulatory enforcement tools are used to force textile firms to reduce water pollution – saving money in the process. One large firm reduced pollution by 90 per cent, energy use by 40 per cent and chemical use by 85 per cent (Robins and Kumar 1999).

Table 7: Selected information-based instruments presents a range of informational tools covering three broad categories of monitoring, engagement and awareness. The instruments selected have either been critical to successful examples of greening cities or have gained particular prominence in the current discourse.

Fuel taxes	Increase fuel tax to internalise external costs of private vehicle use and to adjust demand to the road capacity
Carbon pricing	International, national or regional cap and trade schemes that set a maximum for carbon emissions which are being traded
Pricing for ecosystem services	Payments for ecosystem services (PES) that linking beneficiaries and suppliers of related services
Reduce perverse incentives	Cut tax reductions or incentives that encourage longer commuting (Germany) or single family housing (US)
Tax incentives	Provide funding or tax reductions for citizens or companies investing in renewable energy, retrofitting buildings or other green projects
Road user charges	Managing traffic demand and adjusting vehicle levels to available or reduced road capacities by charging private vehicle use in cities
Parking charges	Charging for on- and off-street parking based on market prices to reduce parking demand and release space for higher value usage
Land development tax	Taxing the release of new land to maximise usage and to contribute to financing green infrastructure development
Land auctioning	Limiting over-consumption of land by capping the release of new land to then be auctioned
Licence plate auctioning	Limiting the growth of private vehicles by capping at certain numbers and auctioning related licences

Table 8: Selected incentives

Taxes	Cities need to be able to raise local taxes and service charges as they are the main revenues sources that can be used for public green city strategies
Cost recovery	Introduce user fees of municipal services to help greening these services and supporting the development of greener alternatives
Land value capturing	Financing public transport based on integrated "transport-property" development models
Micro-financing	Critical financing opportunity where micro-enterprises are involved in green city strategies, e.g. recycling developing country cities
Profit-making public companies	Cities to hold shares of profit making companies, e.g. utilities to allow for long-term green investments
Purchasing pools	Cities can also work together to purchase technology thereby bringing down the cost
Carbon credits	Clean Development Mechanisms (CDM) already pay for a range of green city projects in Bogotá, São Paulo and Dhaka

Table 9: Selected financing instruments

5.6 Incentives

Information alone is insufficient to change behaviour patterns; it needs to be supplemented by incentives to bring about lasting change. In part, this may be to minimise adjustment costs to citizens and firms. For example, firms and workers in brown industries may face higher prices as cities shift their industrial structures towards greener models. National and city-level policy makers need to compensate these short-term losers while recalibrating urban economies.

Incentives may be within the tax system (e.g. tax breaks or taxing environmental "bads"), other types of charges (e.g. road pricing) or payments (e.g. targeted subsidies). Subsidies were successfully used as part of the policy mix in Bavaria during the 1990s and 2000s. The state's Future Bavaria and High-Tech initiatives spent over 4bn Euros, mainly on R&D and technology transfer around the city of Munich. The investments helped kick-start the city's environmental technologies sector, with the city garnering Germany's highest share of cleantech patents in 2007 (Rode et al. 2010).

Apart from providing direct economic incentives, city governments also provide public services – such as workforce education and training, business spaces and green infrastructure. Such services not only reduce the costs to business of going green, but also shift the business environment towards one in which low-carbon activity is the norm.

At the same time, full cost pricing (internalising external environmental costs), whether as taxes or user charges is essential for inducing behaviours to be consistent with green city criteria. Full cost pricing measures have been successful in managing demand for energy, water and other resources and find increasing applications in urban contexts. Many cities in the USA have recently introduced impact fees to recover the cost of additional infrastructure, such as roads, telecommunication, or schools, necessitated by new development (Brueckner 2000). They can also help avoid negative rebound effects with over-consumption as a result of efficiency savings. Furthermore, one such measure – environmental tax – can be used to cut costs for labour, thereby proving an impetus for employment creation.

Major pricing tools in the urban context are presented in Table 8: Selected incentives, which summarises some of the most effective instruments that have brought about sustainable change in examples reviewed in this chapter.

Current job	Core training requirement	Additional low-carbon skill requirement	New low-carbon job
Electrician	Apprenticeship	Working on roofs; installation of solar PV panels	Solar PV fitter
Offshore oil or gas maintenance technician	Apprenticeship	Offshore wind technology	Offshore wind maintenance technician
Aerospace technician	Apprenticeship	Technology-specific knowledge	Wind turbine technician
Architect	Undergraduate degree, masters degree and paid work experience	Energy efficiency and zero-carbon knowledge	Low-carbon architect
City trader	Undergraduate degree	Carbon literacy, understanding or carbon trading schemes	Carbon trader
Facilities manager	No specific qualification required	Sustainability and energy management issues	Low-carbon facilities manager

Table 10: Top-up training for low-carbon jobs
Source: adapted from IPPR (2009)

5.7 Financing

Finance can be a stumbling block to the introduction of concerted policies to shift cities away from a carbon and resource-intensive metabolism. Although several sources of revenues exist, in many countries national fiscal policy prevents local authorities from raising enough capital both, locally and on international financial markets. This has been reinforced in many parts of the developing world by decentralisation reforms that have often entailed a dispersal of central government functions, without any transfer of resources and power to autonomous lower level authorities. Layered on top of this has been the competitive pressure to offer tax concessions in order to attract potential foreign and domestic investors.

Three imperatives are central to advance on green city finance. First, getting a detailed understanding of the existing financial position in terms of potential revenue. This analysis should be based on domestic and international comparison with cities of similar size. Second, city governments need to initiate various forms of partnership with local businesses and community organisations. If cities set the framework for engagement, act transparently and accept the return on investments for private actors, then there is considerable room for leveraging private-sector capital. Third, horizontal and vertical networks are required. According partnerships and coalitions allows for cross-municipal cooperation and regional and international participation in various local government policy forums.

Many of the green city investment projects are within the reach of city governments, which can leverage national or private funds to pay for the initial capital investments. In Hong Kong, the enormous costs for new urban rail infrastructure are covered by the city's principle rail operator, the MTR Corporation, which capitalises on the real-estate potential of its stations as part of an integrated rail-property development model (Cervero and Murakami 2009). In Paris and London, urban bike hire schemes are paid for privately in return for prime advertising space, while the biogas in São Paulo's landfills are a resource that is privately turned into energy and for which the city receives carbon credits. Once the initial investment has been made, these projects bring in a steady revenue stream that can be reinvested. Some projects do not even need initial capital investments as they rely on statutory regulations, such as the green building programmes in Berlin or Austin.

Table 9: Selected financing instruments provides a general overview on financing instruments that have been central to existing green city strategies. In successful cases, many of these tools have been directly available to city governments.

A priority in any green urban planning is investment in cost-effective public transport infrastructure particularly over investment in road construction that further promotes private car use. Surface public transport such as bus rapid transit needs to play a central role particularly in lower income contexts. Non-motorised transport has to be recognised as basis of any transport system and requires greater shares of overall transport budgets.

In both developing and developed countries, another priority is investing in education and training at the city level. Training of workers in green technologies and job skills would be required to ensure that they can access green employment opportunities. Table 10: Top-up training for low-carbon jobs provides some UK examples developed by the Institute for Public Policy Research (IPPR 2009), illustrating the nature and the extent of additional training that will be required to foster a shift towards a lower-carbon economy.

For poorer cities, however, access to finance, green technologies and skills may be out of reach. This is where support in up-front finance, technology, and capacity building is needed from the national government and international community. In the case of climate change, for example, the Copenhagen Accord proposes generating US$ 100 billion per year by 2020 in the support of climate change mitigation and adaptation in the developing world (Glemarec, Waissbein and Bayraktar 2010). Such finance would be particularly effective to enable fast growing cities in the developing world to "leap-frog" developed world cities in planning and installing efficient infrastructure that will reduce resource intensity and save money for decades.

6 Conclusions

Cities are where some of the world's most pressing challenges are concentrated: unsustainable resource and energy consumption, carbon emissions, pollution, and health hazards. But cities are also where hope lies. They are magnets attracting hundreds of millions of rural migrants in search for economic opportunities. The net effect of urbanisation on poverty reduction has been effective at the global level. Although urbanisation has been accompanied by increased pressure on the urban environment and the increase of the urban poor, these problems are not insurmountable.

As the nations of the world explore more sustainable development trajectories, this report argues that cities can and should play a leading role in greening economies – in both developed and developing countries. There are clear opportunities for national and city leaders to exploit urban areas to reduce carbon emissions and pollution, enhance ecosystems and minimise environmental risks.

Greening cities can also produce a set of wider economic and social benefits. First, as well as lowering per capita carbon emissions, densification as a central green city strategy tends to enhance productivity, promote innovation, and reduce the capital and operating cost of infrastructure. Densification can also raise congestion and the local cost of living, but green city strategies and interventions to subsidise housing costs can help to mitigate these.

Second, in most countries cities will be important sites for the emerging green economy. Cities' basic offer of proximity, density and variety delivers productivity benefits for firms, and helps stimulate innovation and new job creation – for example in high-tech clusters, as are already emerging in urban regions like the Silicon Valley. Much of a green economy is service-based, and will tend to cluster in urban areas where consumer markets are largest.

Third, social considerations can be fully integrated into the design of green cities. An emphasis on public transport, cycling, and walkability, for example, not only contributes to road safety and community cohesion but also works in favour of the urban low income class who rely on these transport modes much more than other segments of society. The consequently improved access to jobs, education and medical facilities, clean energy, safe drinking water, and sanitation may hold the key to lifting the urban poor out of poverty altogether.

Greening cities is not cost free. There are tradeoffs and switching costs, creating both winners and losers. Consumer preferences are not always green. Cities may face financial, structural and technological constraints. And fragmented governance may lead to perverse outcomes of policy, if action is not carefully joined up between different spatial levels. The "rebound effect", where energy-saving innovations actually raise total energy consumption, illustrates how many of these issues come together.

These factors suggest it is critical to look at both national and urban policy levers; and at the conditions that will enable cities in different parts of the world to make the transition to green economy models. In practice, green cities will require a coalition of actors across public, private and civil society sectors – and multilevel governance models that allow these actors to come together effectively.

Numerous instruments for enabling green cities are available and tested but need to be applied in a tailored, context-specific way. In contexts with strong local government it is possible to envisage a range of planning, regulatory, information and financing instruments to advance green infrastructure investments, green economic development and a multitrack approach to greater urban sustainability. City governments need to coordinate policies and decisions with other levels of government, but more importantly, they need to be equipped with strategic and integrated planning capacities, including the capacities to choose regulatory tools and economic incentives to achieve locally appropriate green city objectives.

In poorer cities, the building up of such capacities is important, as is their access to financial resources for investing in the various sectors of green cities. Here it may be more prudent to adopt a more pragmatic and minimalist approach, which primarily commits municipal sectors such as water, waste, energy and transport to a limited number of overarching strategic goals. These are the major areas where the support from national governments and international organisations is needed.

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Appendix 1 – Data sources

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