

CHAPTER 1:
COMPETITIVE CITIES IN A CHANGING CLIMATE:
AN ISSUES PAPER¹

As the number of people and the volume and intensity of economic activities in cities grow worldwide, the influence of cities on the local and global environment is rising. The repercussions of this environmental change are felt across all sectors of cities and their hinterlands, as climate change adds to the stress on society, economy, infrastructure and environment. Climate change can affect the competitiveness of cities in the regional, national and international context, because the environmental parameters that influence a city's functioning and the broader global dynamics of production, consumption and exchange of materials, energy and people are also affected.

Cities are centres of financial activity as well as of technological, social and institutional innovation, all of which are essential to their competitiveness at the regional, national and international level. The concentration of population and economic activity lends urban areas a significant role in any national and global effort to cut emissions of greenhouse gases. As they begin to recognize their role as a contributor to global climate change, cities – through intricate changes in behaviour and the built environment – are attempting to cut emissions. But since the accumulation of emissions to date will continue to influence climate for decades, and because cities are often located in vulnerable areas, they must also begin to adapt to the impact of climate change both on the infrastructures that influence urban living and on broader, climate-induced regional, national, and global environmental and socio-economic trends. This paper will sketch the implications of climate change for cities. Section 1 will underline the relevance of cities for climate change; Section 2 will focus on the impact that climate change can have on urban functions; and Section 3 will describe the implications for urban policies. A summary and conclusions will be provided in Section 4.

1. Relevance of cities

1.1 Trends linked to urbanisation

The growing number of urban pockets with very high population densities and compact centres of leisure and economic activities rely on distant resources to remain sustainable. The global ecological footprint is expanding, and cities' competitiveness may be undermined by the depletion of resources and the accumulation of waste by-products. The world's population is projected to increase to 8.2 billion people by the year 2030. Most of the increase will be concentrated in developing nations. Population growth, migration and ageing influence lifestyle and consumption patterns, contributing to the overall strain on the environment (OECD, 2007c). In addition, population density is increasingly concentrated in urban centres, and in urban centres overall, population growth has grown fifteen-fold within the last century.

Urbanisation is linked to concentration of land use, income and economic activity...

By the year 2000, urbanisation had concentrated half of the world's population – nearly 3 billion people – on only 2.8% of the Earth's land area. In Africa and Asia in 2000, 37% of the population was based in urban centres, and in Latin America and the Caribbean, North America, Europe and Oceania, the percentage was in many instances at or above 75% (UNDP, 2003). The average size of the world's largest 100 cities now stands at 5 million (Cohen, 2004) – a 25-fold increase over the figure for 1800.

Cities produce a significant portion of a country's GDP. For example, Budapest, Seoul, Helsinki, Brussels, Oslo, Auckland and Prague generate over one-third of their respective countries' GDP. In most instances, GDP per capita is higher in cities than the national average. Cities attract a more educated demographic. Growth in the labour force tends to be faster in urban areas than in rural areas. Although in nearly two-thirds of metropolitan regions, unemployment is lower than the national average, almost a third of urban areas are experiencing higher-than-average unemployment rates. Additionally, migration from poorer regions to more affluent cities has risen, and many cities have become home to millions of foreign immigrants. While migration generally helps to drive urban economies, its stress on local infrastructure, institutions and services can be significant (OECD, 2006).

Cities tend to concentrate high value-added, low material use and service-oriented industries. These industries and their employees, however, still require significant support from low-skill workers – most of them immigrants – to maintain, improve and expand their services. Low-skill, low-paid workers are often physically segregated in metropolitan regions (OECD, 2006b), and urban poverty levels are on the rise (UNFPA, 2007). Nonexistent or inadequate infrastructure – such as shelter, piped water, sanitation facilities, waste disposal, roads and storm water management systems – increase the vulnerability of many poor areas to local and global environmental change (UNFPA, 2007).

...as well as challenges for social cohesion and increased fossil fuel dependency

The socio-economic inequalities within urban populations contribute to a lack of social cohesion, manifested in increased exclusion, dependency, crime and poverty rates. Additionally, population concentration, as well as economic, leisure and social activities exert pressure on infrastructure, making construction and maintenance more costly and difficult. Congestion and pollution are further externalities related to densely populated areas (OECD, 2006).

Because the growth and development of cities is integrally linked to the availability of affordable energy, demand for fossil fuels in most cities has intensified. This further contributes to climate change, and regional problems such as poor air and water quality also emerge as a result. So while global climate change is a worldwide problem, abating greenhouse gas emissions will help to alleviate many local environmental issues that affect public health and well-being, such as air quality and water pollution.

Cities already concentrate human activity and exert a growing pull on surrounding ecosystems – drawing on natural resources and exporting the waste by-products (OECD, 2007d). With economic growth and the generation of wealth, direct and indirect consumption of energy and materials increase (Ruth, 2007), adding to pressure on water use, waste disposal, energy and transport (OECD, 2007c), and straining local and national budgets.

Urban areas leave a large ecological footprint

The ecological footprint² – the total area required to provide environmental goods and services for a specific region – is particularly severe in cities. For example, in York, England, the city's average

per capita footprint is 25% higher than that of the surrounding region (Barrett *et al.*, 2002). London's footprint was found to be 125 times the size of the city and twice the land size of Great Britain (Wackernagel, 2006; London Remade, 2007), and Cardiff's footprint takes up 82% of the entire land area of Wales (Cardiff Council, 2005).

Figure 1. Progression of ecological unsustainability from 1961 to 2001: footprint and biocapacity

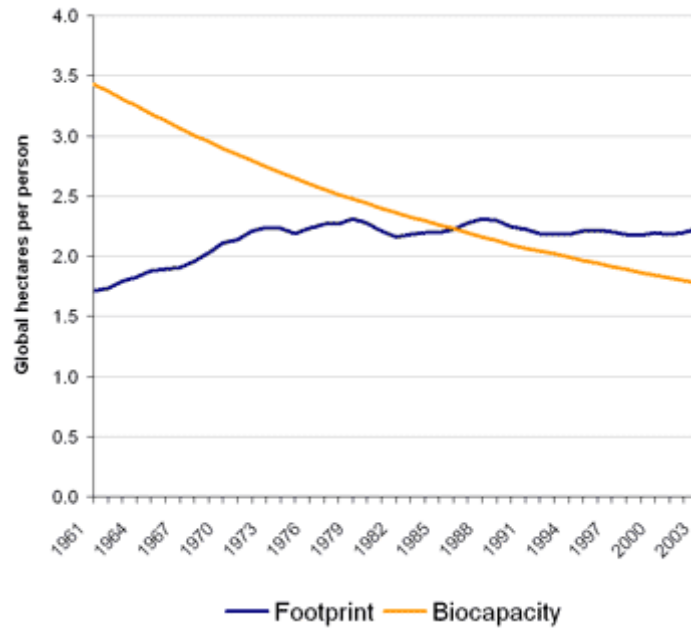


Figure 2. Geographical distribution of the ecological footprint from 1961 to 2001

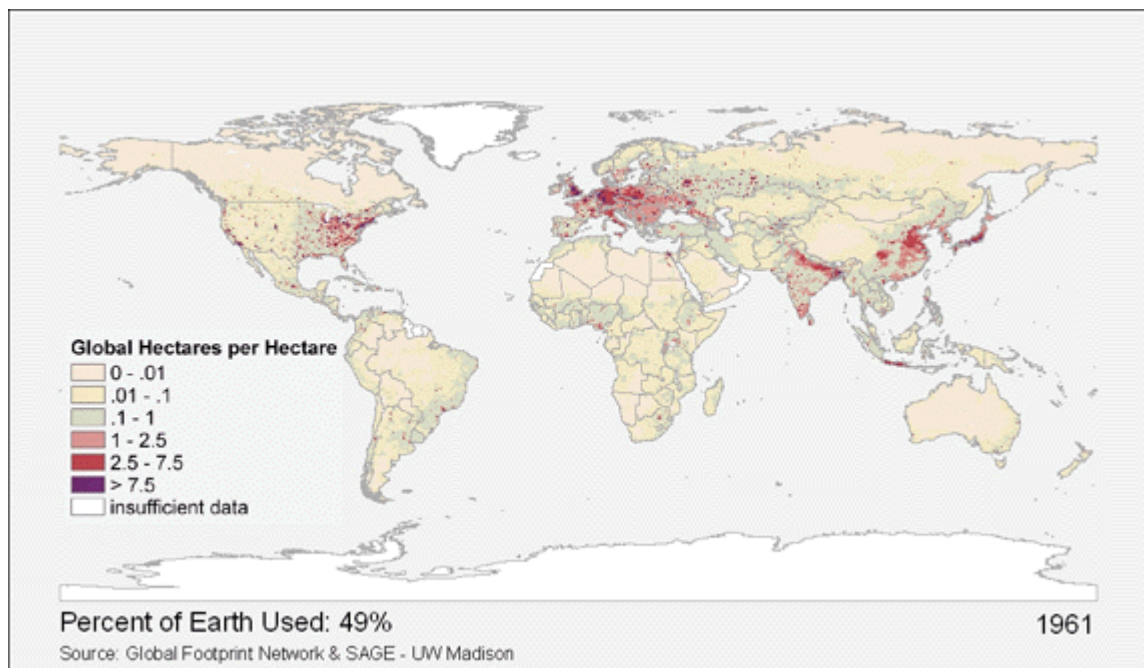
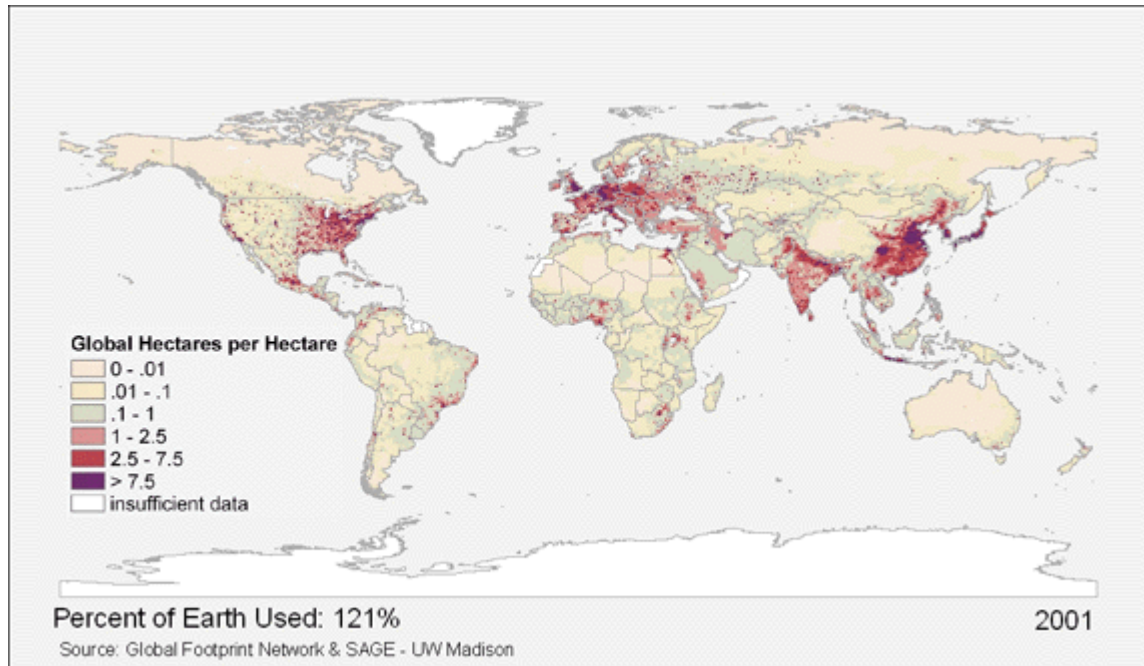


Figure 2. Geographical distribution of the ecological footprint from 1961 to 2001 (cont.)



Source: www.footprintstandards.org.

Urbanisation is associated with higher ecological footprints per capita, primarily because of the high levels of industrial commodity production and the concentration of key consumer markets in urban regions (Jorgensen, 2003). Growth in GDP per capita is similarly associated with increases in global ecological footprint (see Figure 3).

Figure 3. Relationship between urbanisation and GDP per capita with the size of global ecological footprint

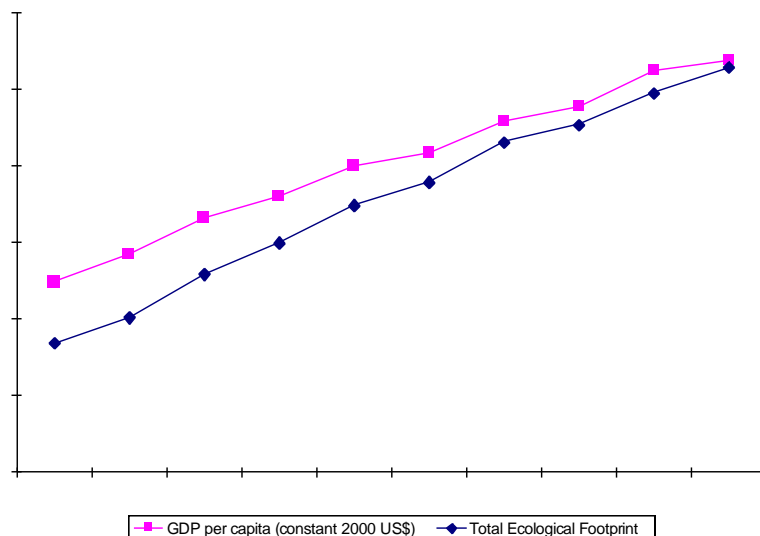
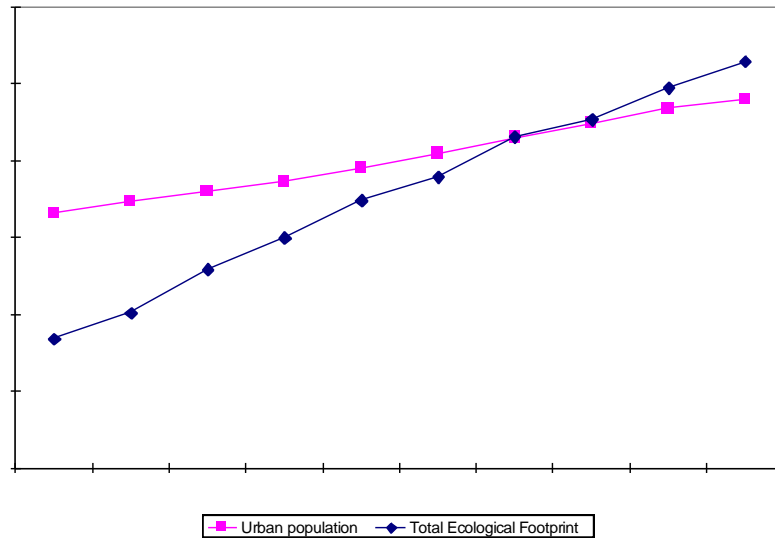


Figure 3. Relationship between urbanisation and GDP per capita with the size of global ecological footprint (cont.)



Source: World Development Indicators Online (2007), The World Bank Group, University of Maryland Library, College Park, Maryland, and Loh, J. and M. Wackernagel (eds.) (2004), *Living Planet Report 2004*, World-Wide Fund for Nature International (WWF), Global Footprint Network, UNEP World Conservation Monitoring Centre, Gland, Switzerland.

The density of demographic and economic parameters in cities, and the corresponding density of physical and intellectual resources, greatly contribute to the continuation of climate change, but also provide an opportunity for an efficient policy response to the challenges of climate change. Local policy makers can take advantage of the factors that drive cities' competitiveness to prepare for the effects of climate change. The concentration in cities of infrastructure, labour, services, buyers and sellers can facilitate "knowledge spillovers" and innovation (World Bank, 2005b).

1.2 Cities as engines of growth

Cities are engines for national growth...

Many cities not only produce a large portion of their country's GDP, as was described in the previous section, but can also act as engines of regional and international growth through effective development and enhancing competition. High productivity, a well-developed infrastructure and supporting industries, social cohesion and investments in human capital, as well as policies designed to reinforce all these elements, are necessary components of city competitiveness.

Studies of GDP per capita in cities within the OECD identify three factors that explain variations in GDP. The most powerful factor, accounting for almost all the variation, is labour productivity, which is GDP per employee. The activity rate (the percentage of the population that is in the labour force) is also correlated with GDP per capita. For cities with low GDP per capita, the employment rate (employees as a percentage of the labour force) has some additional explanatory power (OECD, 2006).

...because they have higher productivity...

The remainder of this section explores factors that contribute to high productivity. Most cities of high productivity within the OECD specialize in high value-added, low-material-use industries, including information technology, financial services, logistics, analytics and biotechnology. They also usually include a thriving sector of specialized consumer goods, such as fashion, arts and marketing. For such activities, the concentration of people and businesses in a large urban area offers many advantages, enhanced by global communications and transportation networks (OECD, 2006). Transportation in particular is vulnerable to climate change, as we discuss later.

...in which transportation, R&D and human capital play a central role

Transportation plays a vital role for cities. The population of urban areas far exceeds what the natural resources within their borders can support. In order to survive at all, cities borrow both the material products of natural systems and ecosystem services from surrounding areas. Some of these items are traded in the market, while others are not, and are the economic externalities stemming from the functioning of the city. For market items such as food or clothing, urban areas borrow ecosystem productivity from all over the globe. This means that they must rely on transportation for very basic functions.

High value-added industries rely on the concentration of research and development activities within the urban area. This, in turn, requires a variety of supporting factors. For instance, the presence of university research centres focused on such industries is critical. Such centres entail a concentration of both physical capital (for example, laboratory space and scientific instruments), as well as the human capital of their highly trained workforces. A diverse manufacturing base is also important for R&D (OECD, 2006). Additionally, many service businesses, such as call centres or IT support from across the globe, have relocated close to pools of cheap, educated labour in developing countries. Many low-wage countries produce large numbers of trained, English-speaking college graduates (Agrawal, 2003). This outsourcing attracts an influx of financial capital from outside the country and often boosts the local economy (Baily, 2004).

Competitive cities need human capital. The economic performance of a city depends on the skills and productivity of its low-skilled workers, as well as on its social cohesion. While investment in human capital raises the skill level of workers, contributing to economic performance, the presence of a large informal economy typically reduces investment in workers' skills, and can reduce a city's competitiveness (OECD, 2006a). Social cohesion and the rule of law, in so far as they limit the informal economy, can be characterized as elements of social capital that aid the competitiveness of a city.

Many factors that contribute to city competitiveness – high productivity, adequate infrastructure (especially of transportation), underlying supportive industries, and social cohesion and human capital investments – are described above. On a basic policy level, increasing such competitiveness requires co-ordinated policy actions designed to provide services at an optimal level, the collection of adequate funding, a mix of tax types, sufficient local autonomy, and limiting urban-made externalities on the rest of the region (OECD, 2006).

1.3 Urban infrastructure and institutions

Although urban infrastructure is an essential element in city competitiveness, cities in many parts of the world are struggling to meet the basic needs of their populations. To plan for and provide the

necessary infrastructure, governments need extensive institutional capability and inter-party co-operation.

Functioning urban infrastructure and a healthy environment not only provide the urban population with the necessary structure for carrying out economic and social activities, but are also prerequisites for ensuring the competitiveness of a city. Disruptions in infrastructure systems create inefficiencies and slow down economic progress, imposing costs on the local and national economy. Cities' stability and prosperity rely on vast networks of provisional infrastructure – solid waste disposal; wastewater treatment; transportation; water, energy and sanitary provisional systems. Urban infrastructure is grossly deficient in many developing countries. As much as 50% of the urban population in Asia and Africa lacks adequate provision of water and sanitary services (Ruth, 2007). Furthermore, if urban growth trends in sub-Saharan Africa follow their projected rates and increase at least 50% between 2000 and 2015, 60% more water will be required to meet the additional demand (Muller, 2007).

Around the world, many urban areas are struggling with deteriorating infrastructure, insufficient public budgets and inefficiencies in privately run services. The underlying causes of inadequate infrastructure are often complex. Government, planning agencies and sometimes non-governmental organisations must assess the adequacy of existing infrastructure. Institutional aptitude and co-operation are particularly necessary in cities to anticipate and respond to environmentally driven challenges, given cities' spatial, functional and economic interconnectedness. Institutions must often struggle to secure adequate funds, correct inequitable access, commit to expensive and irreversible infrastructure investments, and deal with the uncertainty and risk inherent in investment decision-making (Ruth, 2007). In metropolitan regions with overlapping legislative and jurisdictional boundaries, these challenges become ever more difficult.

Investment drivers

Typically, a national government has the authority to make large-scale decisions over infrastructure, although private/government and purely private investments can account for a significant portion of overall infrastructure availability and accessibility. Each of these agents has different investment goals, strategies and tactics. Private/public partnerships often help diversify investment portfolios and spread risk across multiple players, facilitating the provision of infrastructure that is potentially more efficient (Ruth, 2007).

Examples of public-private partnerships abound. Many health care services – for example, through hospitals, mental health care centers and health initiatives (the Global Alliance for Vaccines and Immunisation, the World Health Organization, the TB Alliance, etc.) – are financed and run by public/private partnerships. Transportation networks, including tunnels, roads, motorways, railway stations, bus and rail transit, and bridges are often a co-operative public/private effort. Education, water and energy distributional services, and information technology have also been provided through such collaborations (IP3, 2007).

Ideally, such arrangements combine the advantages of the private sector – capacity for and flexibility in innovation, access to finance, technological competence, and managerial efficiency – with the public sector's mandate to provide services in a socially and environmentally responsible manner (Kumar, 2004). Often, involvement from the private side has been limited to private debt contracts with a select few institutional investors or multilateral banks. Particularly in emerging markets, the public and private sectors wrangled over public control versus investor profits and entitlements; public access to the built infrastructure; inconvenient political realities of privatisation without public input; and sometimes the legal incompatibility of the financing scheme employed. New

partnerships are emerging that rely on local domestic capital spreading risk and benefits among local governments, development banks, international aid agencies and local users. This diversification may deal with some of the concerns outlined above (Streeter, 2004). Regardless of the form infrastructural investment takes – public or private/public partnerships – the presence of an effective and efficient public sector base is vital to a successful outcome.

Obstacles

Governments face several difficulties in planning for and constructing infrastructure. One concern is that rapid population growth and expansion of economic activity quickly makes infrastructural investments inadequate or obsolete. There are several considerations related to the expense, life span, and size and functionality of infrastructure systems. The need for large amounts of financial capital can make infrastructure decisions politically cumbersome. Once investments are made, infrastructure systems become locked in, stalling technological advancement and perpetuating inefficiencies. The relatively long lifespan of most infrastructure introduces investment risks and uncertainties. Furthermore, most infrastructure systems, such as water supply, transportation networks or flood management systems, are large and involve multiple components that must work in co-ordination. Damage to one element can render the entire system dysfunctional. This usually makes investment in redundancy and complementary systems essential, increasing the total cost of a project. In light of these considerations and the projected stress on infrastructure networks stemming from the combination of local influences and global climate change, it is prudent to retrofit current infrastructure and to design systems capable of withstanding the predicted impacts (Ruth, 2007).

Additionally, differentiating and co-ordinating the roles of several tiers of government (local, regional, state and national) can be a daunting task, with their distinctive structures and existing private partnerships. Investment-making involving multiple agencies can be time-consuming and complicated. Another complicating factor in providing adequate infrastructure for local governments is the fact that the essential natural services, such as water aquifers, do not necessarily map onto human-made jurisdictional borders. Many municipalities may rely on a single aquifer – as is the case with the world's largest rivers and lakes. Competing uses of water from the Nile in Egypt and Sudan, the Danube in Europe, the Ganges in India and Bangladesh, and the Colorado River in North America, as well as the Great Lakes in Africa and in North America, illustrate the need for international co-operation and raise questions about the effects of climate change on international relations.

2. The challenges of climate impacts on cities

2.1 Climate variability and change

Some effects of climate change are reasonably predictable (*e.g.*, melting of glaciers, changes in global temperature regimes), while others are not (*e.g.*, frequency and magnitude of extreme weather events). In addition, some are relatively uniform across the globe (sea level rise) while some vary widely from place to place (*e.g.*, heat waves, droughts, spread of alien species and disease). In general, those that show high regional variation are particularly difficult to predict.

Rising sea levels are critical for coastal cities...

Higher global average temperatures and sea level rise are the most widespread and predictable effects. In the twentieth century, the global average temperature has risen 0.6 degrees Centigrade, and even given aggressive measures to curb greenhouse gas emissions, scientists expect an estimated 2.2°C additional rise by 2100, with temperatures continuing to rise for centuries thereafter.³ This can

have a direct effect on human health and energy use (IPCC, 2001c), particularly in urban areas, where it is exacerbated by the heat island effect.

Mean sea level has risen 10-20 centimetres in the 20th century, due to glacial melting and the expansion of sea water as it warms. While the specific amount of melting is difficult to predict, the IPCC expects 30-50 centimetres of sea level rise by 2100⁴ (IPCC, 2001c). This is a critical issue for major cities, which tend to be clustered near coasts, particularly in developing countries. Even in Europe, 70% of the largest cities have areas that are less than 10 meters above sea level (McGranahan, 2007).

Table 1. Cities are highly concentrated in coastal zones

Share of urban settlements whose land area intersects the Low Elevation Coastal Zone (LECZ), by urban settlement size, 2000					
Region	<100K (%)	100–500K (%)	500K–1M (%)	1–5M (%)	5M+ (%)
Africa	9	23	39	50	40
Asia	12	24	37	45	70
Europe	17	22	37	41	58
Latin America	11	25	43	38	50
Australia and New Zealand	44	77	100	100	N/A
North America	9	19	29	25	80
Small island states	51	61	67	100	N/A
World	13	24	38	44	65

Source: McGranahan, G., D. Balk, and B. Anderson (2007), "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones", *Environment and Urbanization*, Vol. 19, International Institute for Environment and Development, London, p. 17.

... and urban infrastructure must be able to handle more extreme weather conditions

Climate variability and extreme weather events are also predicted to increase worldwide. Climate models predict more droughts and more floods, as well as more heat waves and strong wind storms (IPCC, 2001c). While the exact distribution of such effects is highly uneven and very difficult to predict, infrastructures must generally be designed to handle the extremes rather than the average, making cities particularly vulnerable to increasing variability. Much of climate change's damage to ecosystems will be from increasing variability in weather and increasing severity of extreme events (Jones, 2004), and this is likely to be true for human systems as well.

Aside from extreme storms, changes in precipitation patterns will be critical for many regions. Scientists expect a general trend of increased precipitation in middle latitudes and decreasing precipitation near the Equator, but the effects will be highly variable on a local scale, and the technology to predict them accurately does not yet exist (IPCC, 2001c). Changes in the availability of water are more likely to be dominated by the effect of growing populations and economies, but since current water management systems are designed for historical weather patterns, some adjustment will probably be required in most places (Hitz, 2004).

Events that are the least likely to be predicted may also be the most catastrophic, as for example the stalling of the North Atlantic Oscillation or the sudden collapse of ice sheets. Given their unpredictability and relatively sudden and widespread effect, adaptation to such events would require

large investments, all the while running a strong risk of being unnecessary (Jones, 2004). Mitigation measures that reduce the stabilisation level of greenhouse gases will reduce the risk of such events and are the best protection against them.

2.2 Urban climate impacts and vulnerabilities

Section 1.2 discussed factors that contribute to and factors that limit city competitiveness. This section will highlight those factors that are likely to be affected by climate change. Many of the dangers of climate change can be mitigated by folding the expectation of a new climate into existing infrastructure development, although this is complicated by the dense interconnections among the infrastructures on which cities rely (Ruth 2006, Ruth et al. 2006). Where climate change interacts with persistent social problems, adaptation will be even more challenging (Ruth and Ibarra, in press).

Transportation infrastructure is vulnerable to flooding

Transportation infrastructures are critical to cities for their very survival, as well as for competitiveness. Transportation networks are vulnerable to climate change because they are vulnerable to flooding (see Box 1). There is little question that transportation and flood control infrastructure can be built to withstand a wide range of extreme weather events. However, since such infrastructure generally lasts decades, it will be important to take into account predictions for the climate in the future when designing and building the structures. Since these structures will be part of a changing economic and social system as well (and lay the footprint for future development), it will also be imperative to assess them within the longer-term trajectories of socio-economic changes that may occur in response to climate change. In the long view, the best adaptation strategies may turn out to not be technical but socio-economic and institutional in nature.

Box 1. Climate change, transportation and flood risk

New York's airports, as well as many of its power plants and waste transfer facilities, are at sea level and/or on waterfront sites. The subway system and subterranean water and sewer systems were designed for current sea levels. A Category III hurricane would flood all the tunnels out of New York, as well as the city's airports, requiring the evacuation of up to 3 million people (City of New York, 2007).

The Thames Barrier, which protects London from high seas, was raised only three times in its first six years of operation, but was been raised 56 times between 2001 and 2007. Flash floods caused approximately 600 flooding incidents in the London Underground between 1992 and 2003. A single 2002 flooding incident in the Borough of Camden caused traffic disruptions amounting to losses of at least £100,000 per hour's delay on each main road affected, even without including infrastructure damage. A recent report concluded that significant changes to current drainage systems would be needed to maintain current service levels with even a small increase in storm rainfall. (Mayor of London, 2007).

Energy prices will rise, effects on demand are ambiguous

This section summarizes the most vulnerable systems that cities must rely on, both for their existence and in order to compete effectively. It is notable that most of the systems that are not treated here as particularly vulnerable must rely on the continued availability of cheap energy. For instance, as rainfall and temperatures shift, some foods may need to be grown elsewhere. As long as transportation

is relatively cheap, market economies will adjust to this without specific planning or intervention. However, there are several reasons to expect the price of energy to rise.

The largest factor by far is increasing *per capita* energy use in populous developing countries, and increase in population worldwide (Hitz, 2004). There is also evidence that the peak of world petroleum production is approaching, and that additional sources, such as oil shales or tar sands, will be more expensive to exploit (Deffeyes, 2006). In addition, climate change may directly affect the cost of fossil fuel production, as demonstrated graphically by the damage to petroleum platforms in the Gulf of Mexico during the 2005 hurricane season. Hurricane Katrina alone caused nearly USD 11 billion in damages to oil platforms and pipelines (CIER, 2007).

Changing climate may also drive changes in energy demand, which will in turn affect its price. It is not clear whether moderate global warming will increase energy demand or decrease it. As winters warm, less coal, oil and natural gas will be needed for heating. The infrastructure to deliver heating fuels is largely in place and will only be minimally affected by lower utilisation. Cooling requirements, in contrast, are likely to increase considerably, making large-scale investments in cooling efficiency and electricity capacity imperative. Those will, no doubt, have economic implications that far exceed any savings from a reduction in heating costs.

Climate change mitigation measures are likely to impose a cost on emissions from energy use and/or production. This will stimulate efficiency improvement, which will tend to lower demand. The overall effect on energy prices is unclear (see Box 2).

Box 2. Technology

To reduce energy-related carbon dioxide emissions, technological improvements are necessary in the following arenas: reducing the amount of energy required by processes in all sectors; switching energy procurement from coal to oil to gas to renewable energies; increasing efficiency in converting and using energy; and sequestering carbon dioxide (OECD, 2003a).

Establishing a price on greenhouse gases through the market will stimulate behavioral and technological conversion. Optimal timing for mitigation policy should consider the long-term commitments inherent in expensive technological investments. Acting too soon may encourage the development of less than optimal technology, while prolonged inaction will lock society further into high-emitting technologies (OECD, 2003a). Policy options for technology transfer include taxes and other economic instruments that provide incentives for technological efficiency and for research and development investment, voluntary measures and standards, bilateral and regional co-operative efforts on climate change, partnerships with the private sector, and programmes designed to train and educate (OECD, 2003a).

Climate change may put additional strain on social cohesion in cities...

As noted in Section 1.2, social cohesion contributes to city competitiveness. To the extent that the impacts of climate change, or of adaptation to it, are unequally distributed, they may put additional strain on social cohesion. Worldwide, vulnerability to climate increases with population density and poverty (OECD, 2003a; OECD, 2007a). Where a country's low level of development does not allow for expensive infrastructure investments or institutional capacity that can protect the population adequately, a vicious cycle of vulnerability and poverty may result (Ibarraran and Ruth, 2006).

Within countries, studies show that the poor endure higher mortality rates after an environmental disaster. This is primarily because assets and income form the basis of social stability, and secondly, because the poor consistently lack access to credit markets, and government officials and institutions. Furthermore, since the poor generally have little or no savings, their ability to adapt or to move to less vulnerable areas may be limited. To the extent that poverty is correlated with reliance on a single income source, natural disaster will probably undermine livelihoods (Ibarraran and Ruth, 2006). Consequently, as employment opportunities within cities become increasingly specialized, vulnerability may increase. While the distribution of climate change impacts within cities are not well established, it is clear that less well-off residents will have fewer resources for adaptation.

Aside from the distributional inequalities of costs and benefits associated with climate change, mitigation and adaptation policies may also produce imbalances. If a rich developed country chooses to ignore mitigation and pursue only adaptation policies, the costs of mitigation will be shifted to poorer nations and worsen the distributional impacts of climate change (Schneider, 2004). Within metropolitan regions as well, residents with the lowest greenhouse gas emissions per capita are likely to have the fewest resources for coping with climate change. Given their role as social, economic and technological innovators, as well as their particular vulnerabilities, cities will have a key role and responsibility – nationally and internationally – to promote a combination of adaptation and mitigation efforts that help minimize adverse distributional impacts.

...and may intensify competition for water

Since cities rely heavily on ecosystem services outside their boundaries, they are vulnerable to impacts in surrounding regions. For instance, cities generally rely on their immediate surroundings for water. While the effect of climate change on the water resources of a particular city cannot be predicted at present, the competition for water can be expected to intensify in the areas that become dryer than they are now. Areas most likely to be affected include those that rely on snow melt for water over the course of the summer, since winter snow packs in most places will decline (IPCC, 2001a). This will exacerbate the pressure on water resources caused by rising population and affluence (AAAS, 2006).

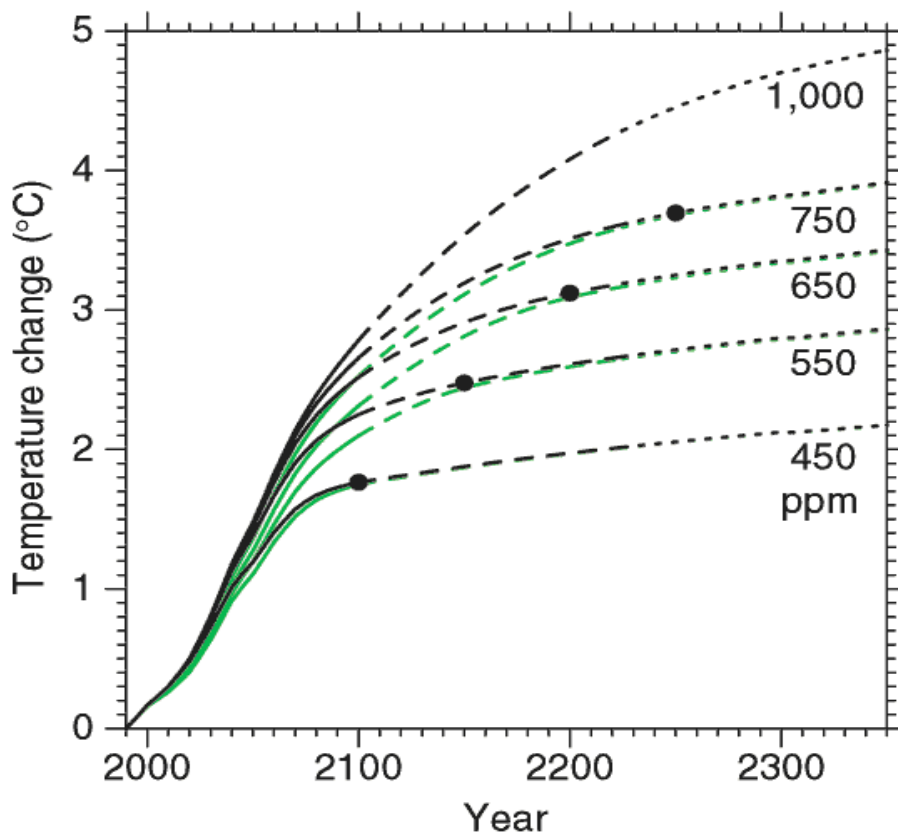
2.3 Mitigation and adaptation measures

Adaptation to climate change and mitigation of climate change are complementary strategies: the investment now of relatively small amounts will avoid larger costs later (see Box 3). Adaptation focuses on expanding the ability to cope with changes in climate,⁵ whereas mitigation focuses on reducing the amount of change through reducing emissions or removing greenhouse gases from the atmosphere through sequestration. Frequently, adaptation and mitigation can go hand in hand, for example when developing a decentralized energy system based on locally available energy sources. Here, greenhouse gas emissions may be lower, as may be the vulnerability to large-area outages from severe weather impacts. The effects of climate change will vary locally, but the causes are global. This means that it is advisable to plan adaptation measures with a bottom-up approach that emphasises local stakeholders and priorities, and mitigation measures with a top-down approach focused on global agreement (Jones, 2004).

Box 3. Mitigation and adaptation are complementary strategies

The more the climate changes, the larger investments cities must make for adaptation. The higher the concentration of greenhouse gases in the atmosphere, the more climate change we can expect. As greenhouse gas release slows and sequestration increases, the world will eventually reach a point at which the concentration of greenhouse gases (GHG) stops rising. The GHG concentration at that point, called the stabilisation level, will determine our new climate. Thus, effective investments in mitigation will reduce the amount we need to invest in adaptation. (Figure from IPCC, 2001b).

Figure 4. Stabilisation scenarios for greenhouse gas emissions



Adaptation implies taking climate change into account in policy making

In many cases, the appropriate measures for adaptation consist of taking climate change into account in building codes, land-use planning and in the planning of new infrastructure or renovating existing infrastructure (Mayor of London, 2007). Transportation and flood control infrastructures, for instance, are usually planned on the basis of historical data that establish the likelihood that a flood of a given size will occur within a certain period. Cities then decide how much to invest in handling a 50-year, 100-year or 500-year flood. However, as climate changes and extreme weather events increase, the incidence of floods of a given size will increase. Infrastructure designed on the basis of historical data may prove insufficient.⁶ For instance, metropolitan Boston may experience what used

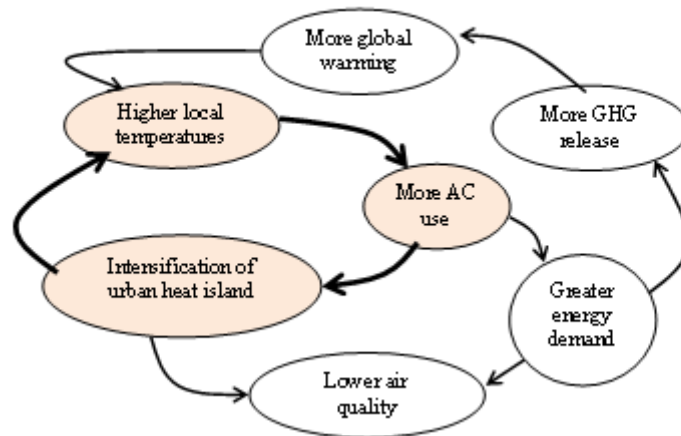
to be 100-year floods as often as every four years by 2100 (Kirshen, 2004). A similar argument can be made for updating building codes to protect against increased extreme weather events.

In choosing a portfolio of mitigation and adaptation measures, it may be necessary to make investment trade-offs between them. However, some policy choices will encourage both mitigation and adaptation. For instance, building codes can also enforce measures for mitigation through lower building energy use, which activates a virtuous cycle of mitigation and adaptation (see Box 4).

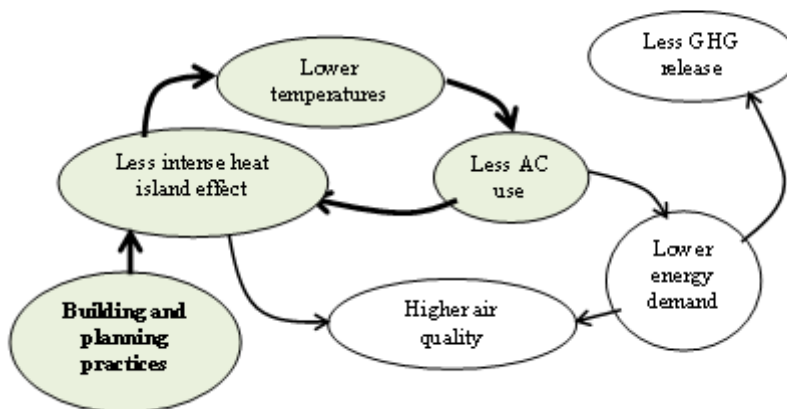
Box 4. The urban heat island effect

The built environment that makes up cities reflects less sunlight, absorbs more heat and retains it longer than vegetation does. In addition, the concentration of energy use leads to a concentration of waste heat. Because of this, cities are consistently several degrees warmer than their surroundings, particularly at night. This exacerbates higher temperatures due to global warming, and participates in several feedback cycles with it.

The vicious cycle of business as usual:



The virtuous cycle of mitigation and adaptation is activated by policies that limit the urban heat island effect, such as green roofs, tree cover and permeable and light-colored surfaces.



Mitigation of climate change might also improve urban liveability and health

Many of the measures that mitigate climate change and that help handle its effects also make cities more liveable and therefore potentially more competitive. For instance, cities can reclaim land in flood plains for open space, including wetlands. This provides an amenity to residents, removes buildings and other infrastructure from flood plains, reduces the urban heat island effect, helps control downstream flooding, provides habitat for animals, and limits water pollution by slowing storm water runoff into large bodies of water. In some cases, this may be integrated into redeveloping abandoned industrial sites.

Mitigating greenhouse gas emissions provides additional public health benefits by reducing many dangerous air pollutants and protecting natural ecosystem services. Often tactics to mitigate greenhouse gases improve national security through reducing dependency on foreign energy sources and by reducing the risks involved in transporting highly combustible fossil fuels around the world (Schellnhuber, 2004).

The problem of infrastructure and climate change is very different for cities in the developed and in the developing world. Highly developed cities have many advantages in institutional and infrastructural capacity for adaptation, from the rule of law to general electrification. On the other hand, it is always easier to change the design of infrastructure for mitigation and adaptation in the planning stage than to alter it once it is in place. In highly built cities, the design of any new infrastructure is constrained by the need to work with what is already in place, making both mitigation and adaptation harder.

3. Implications of climate change for urban policy-making

3.1 Urban climate policy goals

As global, regional, and local environmental challenges grow in size and range, many government environmental agencies have shifted their role from environmental protection providers to environmental policy developers and facilitators (OECD, 2007b). Their exact roles and goals in mediating climate change policy in light of the potential obstacles have to be clearly defined, and the scope of policy determined.

Policies should mitigate climate change and adapt to its irreversible effects...

To comprehensively respond to climate change, policies should be designed to achieve two main objectives – mitigation (through abating existing emissions of greenhouse gases and sequestering atmospheric carbon) and adaptation to irreversible effects of climate change (Schellnhuber, 2004). The inherent uncertainty of climate change scenarios and their impact on policy setting can be dealt with by assessing and assigning probabilities to detrimental impacts; by evaluating critical thresholds; by acting on priority measures that are well-established; and by aggressively mitigating greenhouse gases to avoid the worst effects (Jones, 2004). Not the least, forward-looking cities should embrace the challenge of dealing with climate change. Cities must focus on development of human capital and alleviation of socio-economic vulnerabilities and move away from reliance on competition through material extraction, use and depletion. Development, not growth, is the only truly sustainable way to maintain competitiveness in a world that has finite material resources but infinite intellectual and technological potential.

Just as most policy measures aim to maximize net social benefits, net benefits of adaptation can be determined by comparing adaptation benefits and costs, as well as the unavoidable damages of

climate change, the cost of precaution (if adaptation actions are taken and the climate does not change as predicted) and the cost of caution (if adaptation actions are not taken and the climate does change) (Callaway, 2003). Incorporating the risk of an irreversible catastrophic climate change episode increases the economically optimal level of near-term investments in mitigation and abatement (Corfee-Morlot, 2004). It has in fact been shown that mitigation policy strategies can significantly decrease the possibility of an anthropogenic large-scale climate disturbance (Schneider, 2004). Once the optimal level of action is determined, policy makers can begin to evaluate a programme of policy options necessary to accomplish the goal. Setting a policy agenda that is united across jurisdictions, municipalities and tiers of government is crucial for minimizing negative policy externalities, particularly since many costs and benefits of mitigation policies will probably be decoupled – with costs and benefits distributed unevenly between populations and regions (Corfee-Morlot, 2004).

...despite structural challenges

The ability of policy makers to respond to climate change challenges is often restricted by the existing structural and systematic paradigms. For example, the response of natural resource managers may be constrained by a variety of factors, including limited mobility of resources, the homogeneous, undiversified nature of most natural resource economic sectors, restricted technological possibilities, the high price of environmentally friendly substitutes, inadequate distribution and marketing systems that contribute to deficient domestic markets for a natural resource, and inadequate integration into international product markets. Counteracting these trends may be a prerequisite for implementing a successful climate change policy response in the natural resource sector (Callaway, 2003). More generally, every individual policy arena is operating under an existing paradigm, which may obstruct the successful implementation of climate change policies. This needs to be assessed and acknowledged.

Public authorities at city level often have the necessary jurisdiction (*i.e.*, governmental control, legislative mandate and institutional hierarchy) over the baseline issues underlying many major environmental problems – land-use planning, transport and traffic, building codes and waste management. The combination of these powers can be utilized to institute serious policy actions for sustainability, although implementation is often restricted by funding shortages or inadequate institutional capacity (OECD, 2006).

3.2 Implications for governance paradigms

As city governments move to implement climate change policies, existing relationships with certain economic sectors and other partners will need to be redefined. Governments will need to make decisions on every aspect of policy – from deciding whether to institute top-down or bottom-up controls to the exact nature of the policy tools. Involving the affected parties, the general public, and a mix of policy tools, including market-based solutions, may ease the transitional period.

Because of the likelihood that some industries (particularly fossil fuel-based energy sectors) will incur a financial cost as a result of policy implementations, certain environmental policy reforms will face stiff resistance. Policy tools such as taxes, emissions trading or regulatory standards are often perceived to undermine industries' competitiveness, especially if similar regulations are not required of their international competitors. Impact assessments of new policies that include measuring the potential damages of inaction can help advance a fuller understanding of the urgency and need for action. Additionally, stakeholder involvement and a transparent phasing-in process will be necessary to secure participation and commitment to the policy (OECD, 2007f).

There should be international co-ordination...

However, the most salient response to the concerns of the affected parties is a co-ordinated international effort to ensure fair competition, to buttress a more equitable market system by eliminating market imperfections. Overall, providing better information, paying close attention to policy implementation timing, broad international harmonisation of policy, establishing compensation mechanisms for affected sectors and increasing public awareness must be the foundation of government decision-making and policy implementation. It should be remembered, however, that while some climate policies will introduce new inequalities, the no-policy approach and resultant damages from climate impacts will also affect sectors and individuals unequally.

To implement policy standards on climate change effectively, governments need to consider the level at which to institute these policies. They can be designed to extend top-down or bottom-up – focused on control-and-command policies or voluntary participation; to consist of a single department or be spread across multiple agencies; to be written into legislation; to be tied to budgets; to be open to stakeholders; and to be connected to national, regional, and local policies (OECD, 2007f). City governments face special considerations with regard to their exact jurisdictional authority, available capacity for implementation and enforcement, and co-ordination with the private sector and other affected parties.

...and agreement about targets

Quantified objectives for climate change mitigation involve an agreement upon desirable goals as measured by targets, which could be fixed, dynamic and non-binding, as well as monitored, enforced and adjusted throughout their implementation life cycles (OECD, 2003a). Instituting specific policy requirements, entering into technology agreements, introducing carbon taxes, and targeting specific economic sectors rather than the economy as a whole are additional strategies for reducing greenhouse gas emissions (OECD, 2003a).

Local governments can utilize the market system more efficiently to encourage development of cleaner technologies and assist in technology transfer, through reducing barriers that delay employment of newer technologies (such as revoking outdated subsidies and misplaced incentives) and investing in niche markets. Other tactics include subsidizing research and development, implementing technology and performance standards to reduce unintended environmental externalities, implementing taxes and cap-and-trade systems, and promoting voluntary agreements. These instruments should be used in conjunction with one another, rather than in isolation.

3.3 The costs of inaction

Cities will face many economic costs related to climate change...

There are many significant direct and indirect economic costs related to the impacts of global climate change. Damages to market-priced sectors such as agriculture, forestry and energy are expected to be considerable. But the total cost also includes non-market impacts, because the effects on human health and ecosystems are predicted to be devastating. Additionally, the added uncertainty associated with more frequent extreme weather events and the possibility of a catastrophic event could entail colossal costs of infrastructure rebuilding. Aggregate damages are considered to be underestimated and increasing with time (OECD, 2007e). Costs likely to be incurred if climate change continues unabated include direct financial costs to valuable economic sectors, such as decreased yields for commercial fisheries or disrupted water, energy and transportation infrastructure systems and indirect costs manifested in lost economic activity and productivity (OECD, 2007e).

For example, a recent report from the University of Maryland evaluated the economic impact of climate change on major regions in the United States. It found that as climate change progresses, most economic sectors will be affected – from insurance and infrastructure to manufacturing and agriculture. Billions of dollars in damages are predicted from the increased risk of fires, droughts, agricultural production losses, infrastructure damages and evacuations, and water shortages. Other studies that attempt to quantify the cost of failing to combat climate change project numbers in the trillions. The results of the prominent studies on the subject by Nordhaus and Stern disagree on the figures because of differences in methodology. However, they both conclude that the cost of inaction by far outstrips the losses incurred from policy responses aimed to mitigate and adapt to the event (OECD, 2007e).

...hidden costs...

Most economic loss will come in the form of “hidden” costs. Real costs of rerouting traffic, lost productivity, provision of emergency and continued aid, relocation and retraining costs will be felt throughout a country. In addition, higher risk and uncertainty stemming from global climate change imposes additional costs on the insurance, banking, financing and investment industries (CIER, 2007). In general, these costs will hit cities and their competitiveness.

...costs of lost ecosystems and cultural heritage

Ecosystem damages can be staggering. Over three-quarters of the world’s fish stocks are exploited beyond sustainable levels, causing not only irreversible damage to the integrity of the ocean ecosystem, but inflicting economic costs on coastal and ocean economies. Global climate change is expected to bring additional stress to all ecosystems, and minimizing future costs depends on immediate aggressive policy actions (OECD, 2007e). Unrecoverable loss of environmental resources can seriously undermine important economic sectors in cities and degrade their overall competitiveness in the global economy.

Because of the difficulty of estimating the value of non-market entities and services, costs of lost ecosystems and cultural heritage as well as health-related matters are often ignored in economic studies. However, they may constitute a significant portion of the total damages associated with climate change impacts. Attempts to incorporate some of the relevant costs concentrate on analyzing the market-based constituent elements associated with each system. For example, estimating the costs of water pollution to health involves studying the disruptive economic effects of water-borne illnesses, such as additional health care costs, lost productivity, and the costs of policy control mechanisms employed to tackle the issue. Such intangible factors as discomfort, suffering and loss of life are either crudely measured or ignored. Despite the incomplete availability of costs, studies suggest that inaction on climate change will result in major health costs, by affecting levels of water and air pollution, as well as temperature increases. For instance, total damages from air pollution emitted by the 10 000 largest sources in the United States amount to 0.7 to 2.8% of the country’s GDP. In China, damages from air pollution represent 3.8% of the GDP, and water pollution can cost nearly 2% of GDP (OECD, 2007e).

There are costs of non-implementation

Since emissions and pollution today will have an enduring effect far into the future, the temporal difference in value of money should be considered. It is generally agreed that costs and benefits incurred today have a greater value than those incurred in the future because of the opportunity cost of capital. The difference in the value is measured by the discount rate. Its precise size, however, is

uncertain, and researchers may attribute different rates to it depending on their purpose or preference (OECD, 2007e).

Secondly, since distributional impacts will be uneven within and between countries, certain analyses incorporate equity weighting into their estimates. The presence or absence of the equity weighting element can significantly influence the final results (Pittini, 2004). Thirdly, since the exact shape of adaptation policies is not known, estimates rely on one or two scenarios to predict the outcome. An inherent variability exists in the actual implementation, which make the results less predictable (OECD, 2007e).

Complicating the picture further, environmental impacts are dynamic. Not only do they often exhibit non-linear and cumulative effects, but they have sustainability thresholds and involve irreversibilities. Finally, the exact nature of these dynamic interactions is unknown, as is the likelihood of certain catastrophic events (OECD, 2007e). While it is obviously difficult to project the aggregate costs of inaction on climate change, the final message is clear. The cost of inaction is likely to be monumental and will only increase as global climate change continues.

3.4 Implementation of action plans

Making policies

The implementation of particular climate mitigation and adaptation plans in cities will require agreement on the broad parameters for policy laid out above – the role of public, private and nonprofit sectors in setting a policy course of action, the relative roles of local, national and international communities in identifying and supporting concrete solutions, the relative weight given to technological, social, economic and environmental change in promoting mitigation, adaptation and competitiveness, and the minimisation of negative externalities and inequitable impacts.

The need for pro-active measures...

Anticipatory and pro-active adaptation policies (*i.e.*, those policies that are site-specific, consider local threat extremes, and prescribe strategic investments in preventive mechanisms) minimize maladaptation costs and other inefficiencies compared to passive, reactive policy actions (Schneider, 2004). For example, a study on climate change in Asia, Latin America and Africa found economic benefits of adaptation policies over recovery after the fact (OECD, 2003b).

...and partnerships.

Managing the complexities of the real world necessitates a policy that is designed to work on multiple fronts – involving partnerships with private and non-governmental organisations to work from the bottom up at the local level, as well as incorporating top-down policies and collaborating with regional, national and international players (OECD, 2003a). Technology transfer to developing countries should be encouraged on the international level through grants or preferential or concessional loans. Establishing an international emission-trading framework and assisting developing countries in their participation – potentially through non-binding or dynamic targets – would promote technology transfer (OECD, 2003a). Expansion of public sector capacity through productive and mutually beneficial partnerships within the public sector, as well as with the business community and non-profit organisations, is integral to addressing the complex and expansive impacts of climate change.

One of the persistent barriers to the implementation of environmental policy is the concern that the costs will be too high, reducing economic competitiveness. While there will be losers as well as winners, inaction will entail high costs. OECD analyses show that well-constructed environmental policies have an overall net benefit, and that most disproportionate costs and unequal distributional impacts can be corrected through the use of proper allocation mechanisms (OECD, 2007f). Some strategies to maximize net benefits include gradual policy phase-ins, supplemented by stakeholder involvement and pre-announced schedules; integration of environmental issues into sectoral policy making, allowing each sector to adjust appropriately; support of economic and scientific modeling to better understand the underlying complexities and develop more effective solutions; and enhancement of enforcement systems to ensure compliance (OECD, 2007f). An example of London's plan to respond to climate change is summarized in Box 5.

Box 5. The case of London

The Mayor of London, Ken Livingstone, recently developed an action plan for the city to respond to climate change. In the Mayor's words, "The plan sets out a series of measures...to use energy more efficiently, to change fundamentally the way London is supplied with energy; to maintain London as a world leader in sustainable transport; and to ensure that new development...is of the highest environmental standards." The success of the plan hinges on three factors – a firm commitment from the city to the project; employment of carbon trading and latest investment technologies; and development of new sustainable technologies.

London's plan affects the largest culprits of CO₂ emissions, including energy supply and demand as a primary target. The plan calls for aggressive local decentralisation of wasteful centralized power stations. It encourages the use of combined cooling heat and power (CHP); combining carbon-producing and -consuming sectors to create closed-loop energy systems (*i.e.*, using waste from one to generate energy); production of energy from waste byproducts without incineration; investment, development, and employment of renewable energy sources; and supporting carbon sequestration. Lastly, programmes have been developed to curb private and public citizens' energy consumption (Mayor of London, 2007).

Policy instruments

A full arsenal of policy instruments will need to be employed to mitigate climate change, adapt to the irreversible impacts, and minimize inequitable distribution of benefits and costs, while maintaining city competitiveness and economic security. Mitigation policies will need to address greenhouse gas emissions from existing domestic, commercial, municipal, and industrial activities; new buildings and developments; current energy supply; and ground and air transport. Adaptation policies will need to focus on existing and future infrastructure – including transportation, water and energy networks, and emergency preparedness.

Market-based instruments are promising...

Market-based policy instruments can be valuable tools for implementing abatement of greenhouse gas emissions, but a full understanding of their reach and limitations is required to administer them properly. Generally, the success of market-based instruments depends on three broad parameters – the surrounding policy environment, existing institutional framework and the socio-cultural setting (OECD, 2003a).

Specific policy instruments include carbon/energy taxes, taxes on other gases, voluntary approaches involving government and industry, voluntary approaches through other types of

partnerships (although their effectiveness is in question and should be included as part of a policy package, not as the only response), greenhouse gas emissions trading, energy-efficiency trading, and renewable energy certificate trading. Depending on the specific policy goals, policy instruments should be chosen and evaluated based on their complementarity as well as their individual impacts (see Box 6).

Box 6. Applying policy instruments: The case of India

India's strong economic performance in recent decades has increased its demand for energy, resulting in more greenhouse gas emissions. Two policy instruments designed to abate greenhouse gases are being considered – a price-based approach of introducing emission taxes, and the quantity-based method of launching tradable emission permits. Economically, an emission tax is the more efficient technique in a global abatement system, but because its implementation will entail a large transfer of capital from private firms to governments, such a tax is politically unpalatable. Starting a tradable emission permits system requires a step-by-step approach in India, where command-and-control policies dominate the regulatory spectrum. Instituting carbon taxes should not be entirely avoided. In fact, even marginal taxes can raise significant amounts of revenue. Current subsidies on fossil fuels need to be discontinued, and market-based instruments encouraged (OECD, 2003a).

...and have been implemented in several cities

Another prominent example where a variety of policy instruments has been put in place is London. For example, the city's recently released action plan on global warming tackles private energy consumption through the creation of the Green Homes Programme. The programme provides subsidies and other types of incentives for loft and cavity wall insulation; a "one-stop-shop advice and referral service" for citizens who have questions on implementing energy savings measures; energy-efficiency changes for the city's social housing stock; as well as a public outreach programme to educate and train interested parties on the issue. The business and public sectors will be reached through the Green Organisations Programme. This aims to encourage better buildings partnerships, upgrading and refurbishing buildings to minimize their ecological footprint. An education component of the programme focuses on instituting changes in the operational styles of the buildings, as well as lobbying efforts to support and broaden participation in the programme. Since transportation activities account for a large proportion of greenhouse gas emissions, the London plan considers this as well. The aspects addressed include encouragement of better maintenance and driving practices for private vehicles; promotion of low-emitting vehicles and fuels; employment of carbon pricing for transport; and improvement and support of public transit options.

Tokyo's climate change strategy implements an aggressive CO₂ emissions-cutting approach. It intends to incorporate every economic stratum in the effort – from employing the latest environmental technology to outlining specific involvement from large, medium and small companies and households and designing a private fund to finance the scheme if necessary. The specific instruments Tokyo is implementing are: introduction of a cap-and-trade scheme for the largest CO₂ emitters; promotion of energy conservation measures; work with financial institutions to expand environmental investments and loans; elimination of the use of incandescent light bulbs in households; revitalisation of the solar thermal market; spread of energy-efficient appliances, equipments, and buildings; expansion of the use of hybrid cars; encouragement of private conservation efforts; and the introduction of an "Energy-Efficiency-Promotion Tax System" (Tokyo's climate change strategy).

3.5 Governance challenges

Local governments set and implement a wide range of policy decisions. Traditional wisdom holds that they are better equipped to deliver public goods and services by making use of economies of scale and providing a crucial co-ordinating function to reduce excessive fragmentation and inefficiencies. Additionally, metropolitan institutions can promote redistribution of services between rich and poor areas. Conversely, as municipal governments are often confined by physical boundaries that may not best reflect the needs of the metropolitan region, multi-agency and other co-operative governance frameworks become necessary. Public-private partnerships could also take advantage of economies of scale through contracting and central co-ordination (OECD, 2006).

Vertical co-ordination is essential...

Because different economic sectors, demographic and social patterns, and government structures make up the larger aggregate economy, a co-ordinated response from all levels of government is needed to successfully prevent the most costly scenario. The probable costs of unabated climate change include direct financial costs to valuable economic sectors (such as decreased yields for commercial fisheries and disrupted water, energy and transportation infrastructure) and indirect costs from lost economic and labour productivity (OECD, 2007e). Mainstreaming, co-ordination, and co-operation across government agencies are vital. Moreover, partnerships with the business community, research institutions, non-profit organisations, and trade unions can aid in developing solutions to environmental challenges that benefit all parties (OECD, 2007f).

Regardless of the makeup of government, every element of policy – decision-making, implementation, enforcement, monitoring, review systems, and reporting – requires adequate institutional capacity (OECD, 2003a). Only those cities with such capacity will be able to successfully confront challenges of climate change. One function that will become crucial in addressing upcoming challenges is intersectoral, multilevel co-ordination within the public sector. Successful co-ordination can expand a city's institutional capacity, both through private and non-governmental partnerships working from the bottom up at the local level, as well as top-down policies and collaboration with regional, national and international players (OECD, 2003a).

As central governments spin off environmental governance to local authorities, local jurisdictions can acquire the flexibility and the enforcement mechanisms to create effective policy. The managing role of the central authorities should not be underestimated. Only through co-ordination will it be possible to respond successfully to the impact of global climate change (OECD, 2007f).

...as well as urban funding

Of particular importance is the capability of governments in urban regions to raise the necessary funds. Since local governments rarely have unfettered authority to levy taxes, effective co-ordination with central regional, state and national authorities is crucial. A lack of co-ordination can lead to a multitude of problems related to local fiscal competition, and efforts to avoid such occurrences usually fall within one of three categories. The first method involves tax-base sharing within a metropolitan area. In circumstances where the physical administrative borders traverse metropolitan boundaries, the municipalities within the urban centre agree to share tax proceeds. A more widespread approach is for a higher-level government to divide resources among the local authorities. Another approach involves the establishment of supra-municipal governments that pull in smaller municipal governments under the umbrella of a larger governmental entity. The purpose of these is usually related to providing services, such as water distribution, transportation or waste disposal (OECD, 2006).

One particular aspect with regard to mega-cities should be considered. Studies suggest that the existence of diseconomies of agglomeration – larger populations correlating with lower incomes – after a threshold of around 7 million people. Similar diseconomies may exist for institutions governing the cities (OECD, 2006).

3.6 Compensation for inequitable distribution of climate change impacts

Climate change impacts are predicted to be most costly to the poorest developing regions. For example, the costs of natural disasters – which are predicted to increase in frequency as climate change progresses – can be as high as 13% of GDP in poorest countries. Economic dependence on climatically sensitive sectors such as agriculture is one factor. Another is the inadequate institutional capacity to formulate and oversee policy response mechanisms (OECD, 2007e).

Moreover, as has been discussed, the costs and benefits of climate change policies will probably be disparate, both temporally and geographically. This holds for international policies as well as local and regional measures. These trends could exacerbate poverty in many areas, and to combat the resulting lack of social cohesion, which compromises cities' competitiveness, measures are needed to prevent it from worsening. Financial mechanisms to compensate those who are harmed should be built into climate change policy strategies. These include progressive tariffs, direct subsidies for basic service provisions, and policies restricting disconnection from basic services (OECD, 2007f).

4. Summary and conclusion

4.1 Summary and discussion

Cities play a special role both as drivers of global environmental change and as victims of it. The material and energy requirements of cities, the aggregation of people and the investment in infrastructure all exert influence on local, regional and global resources and waste assimilation capabilities to such an extent that their ecological footprint by far exceeds their spatial extent. As global environmental conditions change, the availability of those resources and waste assimilation capabilities that support urban life may be curtailed. Similarly, global environmental change may alter the location and size of the markets for goods and services generated in cities. At the same time, global environmental change – and particularly the changes in sea levels, water availability and temperature regimes concomitant with climate change – will directly affect cities. Many cities are located on coastlines or major bodies of water and rely heavily on transportation and other infrastructure that is sensitive to weather conditions. Their populations are typically heterogeneous, exhibiting great diversity in income, education, ethnicity, age and aspirations. The institutions that govern that diversity within the given infrastructural, environmental, social and economic constraints are equally diverse, including public, private and nonprofit organisations whose mandates range from local to global concerns. Even under stable conditions, management is a complex task, and it will become all the more difficult given the impact climate has on all aspects of urban activities.

How far cities' competitiveness will suffer depends in part on the rate at which they can adapt to the changes in their environment. As regards resource availability, waste absorption, input and output markets, cities attract the very technologies, institutions, individuals and knowledge that can help to identify solutions. In the long run, the extent to which they can reduce their ecological footprint, and especially their greenhouse gas footprint, will determine whether global climate change can be slowed, halted or even reversed. The longer cities wait to implement strategies to mitigate greenhouse gas emissions, the more they will have sunk into infrastructure, technologies and institutions that maintain or increase emissions of greenhouse gases, and the greater the climate change they will have to adapt to. Greenhouse gases have mean residence times in the atmosphere of more than a century, and every

false step today will make it harder to combat climate change in the future. The costs of undoing damage in the years to come has frequently been overlooked, although it may well be significantly more expensive than the costs associated with climate mitigation.

Even aggressive, immediate action to curb greenhouse gas emissions cannot reverse the climate change caused by emissions to date. Cities will also need to embrace adaptation strategies that reduce current and likely vulnerabilities. In many instances, though, mitigation and adaptation can go hand in hand, and can at the same time maintain or improve competitiveness. A more efficient and robust energy supply will benefit both business and the environment, while a reduction in poverty and social tension will reduce vulnerability to adverse climatic conditions and create an environment that encourages creativity, entrepreneurialism, and economic and social stability.

Many concrete steps towards the design, implementation and administration of mitigation and adaptation measures have already been identified in the literature, and many of them have been discussed in this report. Strategies for mitigating greenhouse gas emissions and for adapting to climate change are evolving through experience, and the policy mix used is changing as a result.

Commonly, voluntary agreements are used to negotiate both incentives for efficient policies (*i.e.*, subsidies for emission abatement), as well as penalties for inefficient policies (targets, timeframes, fines, emission trading, and taxes) (OECD, 2003a). Increasingly, market-based mechanisms are promoted to limit emissions while retaining the maximum freedom of choice among decision makers about the best way – given their individual characteristics – to achieve emissions reductions.

Historically, much of the responsibility for adaptation lay with government institutions. Increasingly, insurances and public/private partnership partake in the effort to reduce vulnerabilities, avoid losses, and undo damages done. Frequently, each level of investment decision-making can include a different partnership with a unique set of challenges and solutions. For example, the initial assessment phase, the planning procedure, the actual construction, the management and monitoring, as well as the decommissioning of the particular infrastructure, may each be done by separate partners. The synergies of the partners' goals and resources should be evaluated and maximized at each phase of the process.

As local, regional and global actors begin to shape strategies for cities in the light of climate change, a host of research questions and management challenges arise. Addressing them thoroughly and in a timely manner will be essential to maintaining and increasing the competitiveness of cities. Several of these challenges are discussed in the remainder of this section.

4.2 Agenda for further research

Several areas for research and management remain that need thorough attention as climate change unfolds around the globe. Among these are the following:

The need for adequate measures of urban economic performance: Currently, GDP per capita is used as a measure of competitiveness. Its neglect of non-marketed goods and services – especially social and environmental ones – skews decision-making towards actions that stimulate economic growth (and thus growth of material and energy use), but do not necessarily stimulate the qualitative improvements that promote sustainable social, economic and environmental conditions. Moreover, measures of economic activity do not take into account the essential social, distributional and environmental issues that may undermine urban resilience in the light of climate change. A lack of multidimensional measures that capture the interrelationship of social, economic and environmental

performance in urban areas tends to favour improved performance (reduced vulnerability and increased competitiveness) judged on the basis of narrowly defined economic criteria only.

The need for better understanding of the relationships among economic sectors of specialisation, city competitiveness, and climate change: As the spatial and temporal resolution of climate impacts increases, city-level investigations are possible that relate urban dynamics to regional and global economic, social and environmental change. Identifying the short and long-term consequences of alternative actions is a process so complex that it is beyond the ability of any individual decision maker. By the same token, the ramifications of any substantive mitigation or adaptation strategy may be so large, like the range of uncertainties in outcomes, that it is advisable to explore alternative scenarios with the help of advanced computer simulation. Simulators are already used to train pilots to fly airplanes, and, properly designed, may be used to hone the decision-making skills of those who “fly” cities. Given the complexity of the challenges at hand, the result of modelled outcomes of alternative actions will not be the “optimal investment” decisions identified by traditional economic modes, but “robust strategies”, *i.e.*, strategies that fare equally well under a wide range of future conditions and evaluation criteria. Embedding the processes by which robust strategies are identified into the learning process of urban institutions will provide the basis for adaptive and anticipatory management of the urban complex.

The need to capture distributional effects of climate change within urban regions: To date, mitigation and adaptation research on climate impacts has barely focused on urban areas in general, or on individual social groups and economic sectors. Yet, the distributional impacts of climate change, as well as mitigation and adaptation measures, will influence current and future social and economic dynamics, and as a result, shape the competitiveness of cities in the region, nationally and internationally. Since it has typically been the distributional implications of policies that guided urban decision-making, it is high time that climate policies connect with real criteria for policy choice.

NOTES

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². Ecological footprint is a uniform measure developed to assess human impact on ecological systems. It consists of six components: the area of cropland required to produce the crops consumed; the area of the grazing land used to produce the animal products; the area of forestland needed to produce wood and paper; the area of sea required to harvest the fish and seafood; the area of land needed for housing and infrastructure; and the area of forest required to sequester the carbon dioxide emitted from energy consumption (Jorgenson, 2003).

³. The temperature rise will not be even, with the largest changes in the middle of mid- and high-latitude land masses in winter (IPCC, 2001c).

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4. This is the variation between emission scenarios; the range including variation between climate models is 9 to 88 centimetres (IPCC, 2001c).
 5. For a rigorous discussion of coping ranges, see Jones (2004).
 6. There may be a reduction of flood risk in some areas, depending on how precipitation patterns change, in which case flood control infrastructure based on historical data would represent an overinvestment.