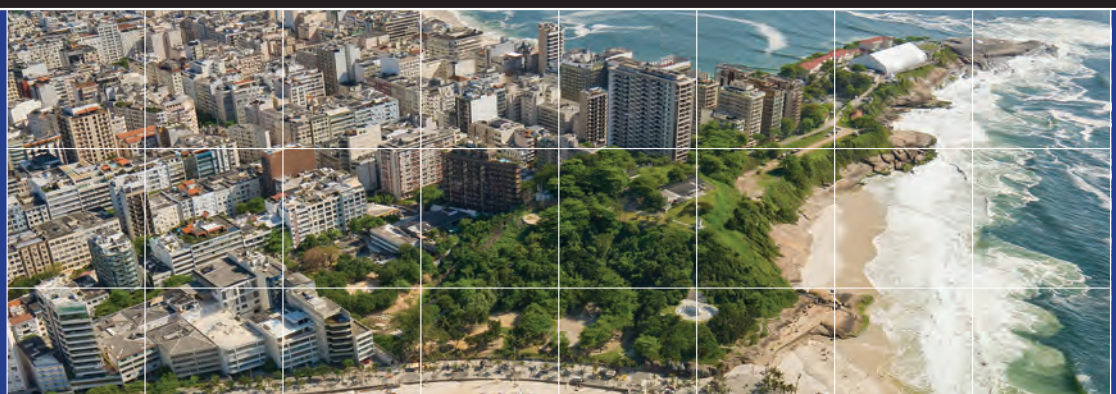
UN-HABITAT

ABRIDGED EDITION

GLOBAL REPORT ON HUMAN SETTLEMENTS 2011

CITIES AND CLIMATE CHANGE: POLICY DIRECTIONS

UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME



CITIES AND CLIMATE CHANGE: POLICY DIRECTIONS

GLOBAL REPORT ON HUMAN SETTLEMENTS 2011

Abridged Edition

United Nations Human Settlements Programme

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CONTENTS

INTRODUCTION

The effects of urbanization and climate change are converging in dangerous ways that seriously threaten the world's environmental, economic and social stability. *Cities and Climate Change: Global Report on Human Settlements 2011* seeks to improve knowledge, among governments and all those interested in urban development and in climate change, on the contribution of cities to climate change, the impacts of climate change on cities, and how cities are mitigating and adapting to climate change. More importantly, the Report identifies promising mitigation and adaptation measures that are supportive of more sustainable and resilient urban development paths.

The Report argues that local action is indispensable for the realization of national climate change commitments agreed through international negotiations. Yet most of the mechanisms within the international climate change framework are addressed primarily to national governments and do not indicate a clear process by which local governments, stakeholders and actors may participate. Despite these challenges, the current multilevel climate change framework does offer opportunities for local action at the city level. The crux of the challenge is that actors at all levels need to move within short time frames to guarantee long-term and wide-ranging global interests, which can seem remote and unpredictable at best.

An important finding of the Report is that the proportion of human-induced (or anthropogenic) greenhouse gas (GHG) emissions resulting from cities could be between 40 and 70 per cent, using production-based figures (i.e. figures calculated by adding up GHG emissions from entities located within cities). This is in comparison with as high as 60 to 70 per cent if a consumption-based method is used (i.e. figures calculated by adding up GHG emissions resulting from the production of all goods consumed by urban residents, irrespective of the geographic location of the production). The main sources of GHG emissions from urban areas are related to the consumption of fossil fuels. They include energy supply for electricity generation (mainly from coal, gas and oil); transportation; energy use in commercial and residential buildings for lighting, cooking, space heating, and cooling; industrial production; and waste.

However, the Report concludes that it is impossible to make accurate statements about the scale of urban emissions, as there is no globally accepted method for determining their magnitude. In addition, the vast majority of the world's urban centres have not attempted to conduct GHG emission inventories.

The Report argues that, with increasing urbanization, understanding the impacts of climate change on the urban environment will become even more important. Evidence is mounting that climate change presents unique challenges for urban areas and their growing populations. These impacts are a result of the following climatic changes:

- Warmer and more frequent hot days and nights over most land areas;
- Fewer cold days and nights in many parts of the world;
- Frequency increases in warm spells/heat waves over most land areas;
- Increased frequency of heavy precipitation events over most areas;
- Increase in areas affected by drought;
- Increases in intense tropical cyclone activity in some parts of the world; and
- Increased incidence of extreme high sea levels in some parts of the world.

Beyond the physical risks posed by the climatic changes above, some cities will face difficulties in providing basic services to their inhabitants. These changes will affect water supply, physical infrastructure, transport, ecosystem goods and

services, energy provision and industrial production. Local economies will be disrupted and populations will be stripped of their assets and livelihoods.

The impacts of climate change will be particularly severe in low-elevation coastal zones, where many of the world's largest cities are located. Although they account for only 2 per cent of the world's total land area, approximately 13 per cent of the world's urban population lives in these zones – with Asia having a higher concentration.

While local climate change risks, vulnerabilities and adaptive capacity vary across cities, evidence suggests some key common themes. First, climate change impacts may have ripple effects across many sectors of city life. Second, climate change does not impact everyone within a city in the same way: gender, age, race and wealth have implications for the vulnerability of individuals and groups. Third, in terms of urban planning, failure to adjust zoning and building codes and standards with an eye to the future may limit the prospects of infrastructure adaptation and place lives and assets at risk. Fourth, climate change impacts can be long-lasting and can spread worldwide.

In proposing the way forward, following a global review of climate change mitigation and adaptation measures taken by cities all over the world, the Report emphasizes that several principles are fundamental to an integrated, multipartner approach towards climate change action at the urban level:

- No single mitigation or adaptation policy is equally well-suited to all cities;
- It would be beneficial to take an opportunity/risk management approach in a sustainable development perspective, considering not only emissions, but also risks that are present in a range of possible climate and socioeconomic futures;
- Policies should emphasize, encourage, and reward 'synergies' and 'co-benefits' (i.e. what policies can do to achieve both developmental and climate change response goals);
- Climate change policies should address both near-term and longer-term issues and needs; and
- Policies should include new approaches that support multiscale and multisector action, rooted in the different expectations of a wide range of partners.

The Report suggests three main areas in which the international community can support and enable more effective urban mitigation and adaptation responses:

- Financial resources need to be made more directly available to local players – for example, for climate change adaptation in vulnerable cities, for investment in a portfolio of alternative energy options, and in mitigation partnerships between local governments and local private sector organizations;
- Bureaucratic burdens on local access to international support should be eased, with the international community helping to create direct communication and accountability channels between local actors and international donors; and
- Information on climate change science and options for mitigation and adaptation responses should be made more widely available by the Intergovernmental Panel on Climate Change (IPCC), the United Nations and other international organizations, including available knowledge on observed and future climate impacts on urban centres, on urban-based mitigation and adaptation alternatives, and on the costs, benefits, potentials and limits of these options.

With respect to the national level, the Report suggests that national governments should use the following mechanisms to enable mitigation and adaptation actions at the local level:

- Engage in the design and implementation of national mitigation strategies and adaptation planning;
- Offer tax rebates, tax exceptions and other incentives for investments in alternative energy sources, energy-efficient appliances, and climate-proof infrastructure, houses and appliances, among other climate change mitigation and adaptation actions;

- Encourage appropriate climate responses (for example, redesign policies enacted with other issues in mind or in periods prior to climate change, such as flood protection policies that can result in maladaptations);
- Enhance coordination and streamlining between sectoral and administrative entities (for instance, make sure that decisions by one city to protect coastal areas with barriers do not have impacts on basins that are suppliers of fresh water, or wetland ecologies that are important to the economic base of that city or other cities inland);
- Develop partnerships with non-governmental actors to share risks (for example, national governments can work with private insurance providers to offer protection to each city without requiring each to make a sizeable investment in order to reduce risks from a particular kind of low-probability threat); and
- Anticipate and plan for the possibility of much more substantial climate change impacts and adaptation needs in the longer term than those that are currently anticipated in the next decades.

For the local level, the Report suggests, broadly, that urban policy-makers should begin from an awareness of local development aspirations and preferences, local knowledge of needs and options, local realities that shape choices, and local potential for innovation. In this context, urban local authorities should:

- Develop a vision of where they want their future development to go and find ways to relate climate change responses to urban development aspirations;
- Expand the scope of community participation and action by representatives of the private sector, neighbourhoods (especially the poor) and grassroots groups, as well as opinion leaders of all kinds, in order to ensure a broad-based collection of perspectives; and
- Using an inclusive, participatory process, cities should conduct vulnerability assessments to identify common and differentiated risks to their urban development plans and their different demographic sectors, and decide on objectives and ways to reduce those risks.

To achieve more effective policies, local governments need to expand the scope, accountability and effectiveness of participation and engagement with non-governmental organizations (NGOs), such as community and grassroots groups, the academic sector, the private sector and opinion leaders. Effective engagement with NGOs will serve multiple purposes:

- It will become a source of innovative options, as well as both scientific and locally relevant knowledge;
- It will allow participants to understand and mediate the diverse perspectives and interests at play; and
- It will provide broad-based support for decisions and promote knowledge on the causes of emissions and vulnerabilities, as well as mitigation and adaptation options thus achieved.

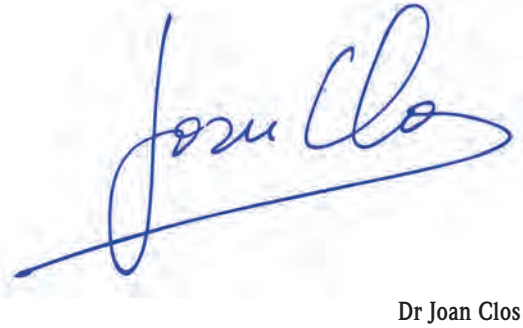
Partnerships with the private sector and NGOs are of special relevance in this context. For example:

- Resources from international, national and local private organizations can be mobilized to invest in the development of new technologies, housing projects and climate-proof infrastructures, and to assist in the development of climate change risk assessments; and
- The widespread involvement of NGOs in climate arenas as diverse as climate awareness and education and disaster relief should be welcomed – the inputs and perspectives of these organizations can be harnessed to help develop a more integrated urban development planning.

Finally, the Report suggests that broad-based oversight organizations, such as advisory boards, representing the interests of all actors, should be created to help avoid the danger that private or sectarian interests may distort local action (for instance, by investing in technologies, infrastructures and housing that only benefit a minority, or by hijacking the benefits of grassroots funding). This is especially of concern in urban areas within countries that have experienced strong

centralized control in the hands of local elites and state agents, but the principle of broad-based oversight can and should be practised everywhere.

Many towns and cities, especially in developing countries, are still grappling with the challenges of how to put in place climate change strategies, how to access international climate change funding and how to learn from pioneering cities. I believe this Global Report will provide a starting point for such towns and cities. More generally, I believe this Report will contribute to raising global awareness of the important role that cities can and should play in the mitigation of greenhouse gas emissions and in adapting to climate change.



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1 The HS-Net Advisory Board consists of experienced researchers in the human settlements field, selected to represent the various geographical regions of the world. The primary role of the Advisory Board is to advise UN-HABITAT on the substantive content and organization of the Global Report on Human Settlements.

CHAPTER 1

URBANIZATION AND THE CHALLENGE OF CLIMATE CHANGE

Humanity faces a very dangerous threat. Fuelled by two powerful, human-induced forces that have been unleashed by development and manipulation of the environment in the industrial age – the effects of urbanization and climate change are converging in dangerous ways. The results of this convergence threaten to have unprecedented negative impacts on quality of life, and economic and social stability.

However, alongside these threats is an equally compelling set of opportunities. Although urban areas, with their high concentration of population, industries and infrastructure, are likely to face the most severe impacts of climate change, urbanization will also offer many opportunities to develop cohesive mitigation and adaptation strategies to deal with climate change. The populations, enterprises and authorities of urban centres will be fundamental players in developing these strategies.

While some cities are shrinking, many urban centres are seeing rapid and largely uncontrolled population growth, creating a pattern of rapid urbanization. Most of this growth is now taking place in developing countries and is concentrated in informal settlements and slum areas. Therefore, the very urban areas that are growing fastest are also those that are least equipped to deal with the threat of climate change. These areas often have profound deficits in governance, infrastructure, and economic and social equity.

As climate change is quickly building momentum the magnitude of many of the threats to urban areas is increasing. These impacts will fall disproportionately on the urban poor in developing as well as developed countries. Destruction of property and loss of life in coastal areas, and elsewhere, will certainly not be limited to the poor, but affluent segments of

Urbanization and climate are converging in dangerous ways

Ecozone	Year	Share of urban population (%)						
		Africa	Asia	Europe	North America	Oceania	South America	World
Coastal	2000	62	59	83	85	87	86	65
	2025	73	70	87	89	90	92	74
Low-elevation coastal zone	2000	60	56	80	82	79	82	61
	2025	71	68	85	86	83	90	71
Cultivated	2000	38	42	70	75	67	67	48
	2025	48	55	75	81	72	80	59
Dryland	2000	40	40	66	78	49	61	45
	2025	51	51	70	84	60	75	55
Forested	2000	21	28	53	64	36	53	37
	2025	31	41	59	72	40	68	47
Inland water	2000	51	47	78	84	77	71	55
	2025	62	58	82	88	80	83	64
Mountain	2000	21	27	46	50	11	54	32
	2025	30	40	53	60	13	67	43
Continent average	2000	36	42	69	74	66	66	49
	2025	47	55	75	80	70	78	59

Source: Balk et al, 2009

Table 1

Urban population in different 'ecozones', by region (2000 and 2025)

the population will be much better protected by insurance as well as political and economic advantages.

URBANIZATION AND CLIMATE CHANGE

It is important to understand the forces shaping the world's growing urban areas in order to be able to mitigate climate change and to cope with its inevitable consequences:

- The pace or urbanization in the world today is unprecedented, with a near quintupling of the urban population between 1950 and 2011.
- The fastest rates of urbanization are currently taking place in the least developed countries, followed by the rest of the developing countries – comprising three quarters of the world's urban population.
- While the populations of some cities are shrinking, the number of large cities and the size of the world's largest cities are increasing with the bulk of new urban growth taking place in smaller urban areas.
- Since urban enterprises, vehicles and populations are key sources of greenhouse gases (GHGs), understanding the dynamics of urban GHG generation is critical.
- Cities are centres of diverse innovations that may contribute to reducing or mitigating emissions, adapting to climate change, and enhancing sustainability and resilience.
- The dynamics of urban centres are intimately linked to geography, including climate and location in relation to natural resources.

Many weather-related risks – which already have an urban face (see Table 1 and Figure 1) – will be exacerbated as climate change progresses and hazards such as rising temperatures, increasingly severe weather patterns, sea-level rise, saltwater intrusion and more intense storms become day-to-day realities for the poor and vulnerable populations in urban centres. Urbanization, however, is not only a source of risks – certain patterns of urban development can increase resilience.

EVIDENCE OF CLIMATE CHANGE: IMPLICATIONS FOR URBAN CENTRES

It is now undeniable that the Earth's climate is warming. This is evident from models and observations at global and continental levels, and from the work of the Intergovernmental Panel on Climate Change (IPCC), according to which there was an increase of 0.74°C between 1906 and 2005. Urban centres have played a key role in this

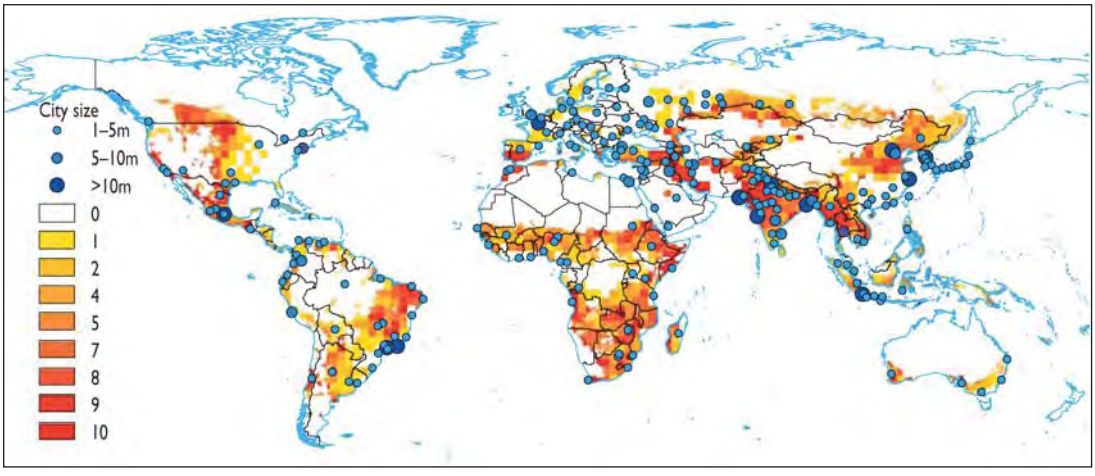

Figure 1

Cities in relation to current climate-related hazards

Note: The urban areas included in this figure have populations greater than 1 million. The hazard risk represents a cumulative score based on risk of cyclones, flooding, landslides and drought. A score of '0' denotes 'low risk' and '10' denotes 'high risk'.

Source: Based on de Sherbinin et al, 2007, Figure 1

process, although the extent of their role is not yet fully understood.

Human activities such as the combustion of fossil fuels, large-scale industrial pollution, deforestation and land-use changes, among others, have led to a build-up of GHGs in the atmosphere together with a reduction of the capacity of oceans and vegetation to absorb GHGs. This has reduced the Earth's natural ability to restore balance to the carbon cycle and is now resulting directly in the current global changes in average temperatures.

The most important types of GHGs produced by human activities are CO_2, methane, nitrous oxide, and halocarbons and other fluorinated gases. These gases do not all have the same impacts on climatic change, so are often described using their CO_2 equivalent value (CO_2eq), which is a useful tool for comparing emissions.

Not every country has contributed at the same level to global warming. Developing countries generated only 25 per cent of the per capita emissions of developed countries. A select number of developed countries and major emerging economy nations are the main contributors to total CO_2 emissions. These uneven contributions are at the core of both international environmental justice issues and the challenges the global community faces in finding effective and equitable solutions.

Urban sprawl is contributing to increased GHG emissions

The rising consumerism of urban elites drives GHG emissions

Humanity is therefore facing two main challenges that urban centres can help address: there is a need to adapt to climate change, but there is also an urgent need to mitigate those human-induced forces driving climate change. Specifically, urban areas can help to achieve a development path that would keep global average temperature increases within 2 to 2.4°C above pre-industrial levels, in keeping with the objective outlined in the United Nations Framework Convention on Climate Change (UNFCCC), Article 2.

FRAMEWORK FOR EXPLORING THE LINKAGES BETWEEN URBAN AREAS AND CLIMATE CHANGE

The exploration of how urban centres contribute to climate change requires an understanding of how transportation, heating and cooling systems, industries and other urban activities and infrastructures act as emitters and as direct causes of climate change. Urban centres create two main categories of impacts on the carbon cycle and the climate system, namely changes related to the emission of aerosols, GHGs and solid wastes; and land-use related changes.

Within cities, the contribution of different populations, economic activities and infrastructures to global warming is differentiated due to several interrelated factors that determine patterns of energy use and emissions. The climate and natural endowments and economic base of a city significantly shape energy-use patterns and GHG emissions. Moreover, affluence has been repeatedly acknowledged as a significant driver of GHG emissions, along with the size, growth, structure and density of the urban population. Some studies point to the fact that gender inequities exist both in energy use and GHG emissions and that the differences are related not only to wealth but also to behaviour and attitudes. Studies show that a negative correlation exists between population density and atmospheric GHG emissions; spatially compact and mixed-use urban developments have generally significant benefits in terms of GHG emissions.

Urban development can bring increased **vulnerability** to climate hazards, but a focus on the exposure of urban settlements to climate change hazards alone is insufficient to understand climate change impacts. Attention to urban

Climate change impacts will fall disproportionately on the urban poor

resilience, development, socio-economic and gender equity, and governance structures as key determinants of adaptive capacity and actual adaptation actions is also necessary.

Not all demographic segments of urban populations are equally affected by the hazards aggravated by climate change. The capacity of different urban populations to cope or adapt is influenced not only by age and gender, but also by one or a combination of many factors including human, financial, physical, natural and social capital. Evidence suggests that while wealthier groups are less vulnerable, women, the elderly, children, minority groups and the urban poor have particular vulnerabilities.

ORGANIZATION OF THE REPORT

The report is organized as follows:

- Chapter 2 focuses on the international climate change framework and the implications, opportunities and challenges it offers for urban action.
- Chapter 3 examines the contribution of urban areas to climate change.
- Chapter 4 describes how climate change may exacerbate the physical, social and economic challenges cities are currently experiencing.
- Chapter 5 focuses on climate change mitigation and presents a comparative analysis of emerging trends in urban mitigation responses.
- Chapter 6 looks at urban adaptation to climate change and examines the relative roles and potential partnerships between stakeholders.
- Chapter 7 summarizes the key findings of the report, looking at the constraints, challenges and opportunities for mitigation and adaptation actions.

CHAPTER 2

CITIES AND THE INTERNATIONAL CLIMATE CHANGE FRAMEWORK

Responses to the climate change challenge are taking place within the context of an international framework that shapes related actions and decisions at all levels. This framework is defined here as the spectrum of agreements, mechanisms, instruments and actors governing and driving climate change action globally. The overall structure of this framework is complex and multidimensional. While international agreements negotiated by national governments such as the UNFCCC and its Kyoto Protocol remain crucial aspects of the framework, they are not the only mechanisms governing climate change action.

Cities have a vital role to play in the implementation and achievement of commitments within the international climate change framework. They also stand to benefit from the opportunities created by this framework for local responses to climate change. However, many decision-makers operating at the city level lack a working knowledge of the opportunities and constraints associated with international financing options, including those established as part of the UNFCCC.

THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The ultimate objective of the UNFCCC is to stabilize global GHG concentrations at a level that would prevent human interference with the climate system. Its efforts to curb emissions are premised on some explicit and implicit norms which have become fundamental to the international climate regime. Chief among these are the principle of 'common but differentiated responsibilities and respective capabilities' and the 'precautionary principle' whereby even in the absence of full scientific certainty, countries are obliged to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects.

Signatories to the UNFCCC are required to provide regular inventories of their GHG emissions, using 1990 as the base year for these tabulations. In 1997, the principles under the UNFCCC were finally translated into legally binding commitments through the Kyoto Protocol.

In addition to its focus on emissions reduction, the UNFCCC also seeks to support adaptation activities in

Box 1 Funding mechanisms of the UNFCCC

The **Special Climate Change Fund** is intended to finance activities related to adaptation, technology transfer and capacity-building, energy, transport, industry, agriculture, forestry, waste management and economic diversification.

The **Least Developed Countries Fund** aims to assist 48 least developed countries to prepare and implement 'National Adaptation Programmes of Action' through which they identify priority adaptation activities for funding.

The **Adaptation Fund** was established to finance adaptation projects and programmes in developing countries that are especially vulnerable to climate change impacts. It is to be funded from a 2 per cent levy on all 'Clean Development Mechanism' project activities (see Box 2).

Box 2 Flexible mechanisms under the Kyoto Protocol

The three flexible mechanisms of the Kyoto Protocol are as follows:

- The **Clean Development Mechanism** (CDM) enables emission-reduction projects in developing countries to earn 'certified emission reduction' credits which can then be traded or sold.
- **Joint implementation** allows developed countries to invest in emissions reduction activities in other developed countries. A developed country can thus earn 'emission reduction units' from an emission reduction or emission removal project in another developed country, which can be counted towards meeting its Kyoto target.
- **Emissions trading** allows developed countries that exceed their target emissions to offset them by buying 'credits' from countries that stay below their emission targets. For the five-year compliance period from 2008 until 2012, countries that emit less than their quota will be able to sell emissions credits to countries that exceed their quota.

developing countries through specialized funding mechanisms for adaptation: the Special Climate Change Fund, the Least Developed Countries Fund and the Adaptation Fund (see Box 1).

THE KYOTO PROTOCOL

The Kyoto Protocol entered into force on 16 February 2005. According to the protocol, developed countries commit to reduce their overall GHG emissions by at least 5 per cent below 1990 levels during the commitment period from 2008 to 2012. After Australia's ratification of the protocol in 2007, the US is the only developed country not to have ratified the Kyoto Protocol.

Although countries are expected to meet their mitigation targets primarily through national programmes, the protocol also enables them to cut their emissions through three flexible mechanisms namely the 'Clean Development Mechanism' (CDM), 'joint implementation' and 'emissions trading' (see Box 2).

There is now considerable uncertainty as to whether the international community will be able to reach a legally binding agreement to replace the Kyoto Protocol after 2012. Failure to do so could lead to further fragmentation of the global framework for climate change governance.

Progress with international climate change negotiations has been slow

Demand for government action on climate change is on the rise

OTHER CLIMATE CHANGE ARRANGEMENTS

The last two decades have witnessed the multiplication of other regional, national and local (e.g. city) mechanisms and actors responding to the climate challenge. These include initiatives of multilateral and bilateral entities, sub-national tiers of government, grassroots groups, private enterprises, non-governmental organizations (NGOs) and individuals.

International level

The **United Nations** is one of the key climate change actors at the international level. In addition to its work through the UNFCCC and the IPCC (see Box 3), a number of its programmes and other entities are contributing to the global response to climate change. The United Nations has been performing a crucial role in steering and coordinating climate change action internationally. It has also been at the forefront of generating scientific knowledge on climate change to support international negotiations and evidence-based policy-making. Agencies such as the United Nations Environment Programme and the World Meteorological Organization have been centrally involved in numerous global and national initiatives, along with other ongoing interventions and campaigns led by, among others, UN-Habitat, the United Nations Development Programme, and the Food and Agricultural Organization.

The United Nations has also been playing a leading role in terms of disaster risk management, which is fundamental to climate change adaptation efforts. The International Strategy for Disaster Reduction, which was adopted in 2000, is a system of partnerships between local, national, regional and international organizations with the overall objective of supporting global disaster risk reduction.

Other multilateral institutions are playing an increasingly important role in climate change adaptation and mitigation at various levels. They have especially become a prominent source of financial and technical assistance for climate change action in developing countries. The World Bank Institute is implementing city-focused climate change activities through various mechanisms and initiatives, including: the 'Carbon Finance Assist Programme'; the 'Carbon Finance Capacity Building' programme for emerging megacities; the 'Mayors' Task Force on Urban Poverty and Climate Change'; the 'Clean Energy Investment Framework'; the 'Strategic Framework'; and the 'Climate Investment Fund'.

Box 3 The Intergovernmental Panel on Climate Change

The IPCC was created in 1988 by the World Meteorological Organization and the United Nations Environment Programme in order to keep world governments informed of climate change issues. The IPCC's 194 member countries meet once a year during sessions also attended by numerous other institutions and observer organizations. The United Nations General Assembly resolution 43/53 of 6 December 1988 states that the role of the IPCC is to '*provide internationally co-ordinated scientific assessments of the magnitude, timing and potential environmental and socio-economic impact of climate change and realistic response strategies.*'

The IPCC analyses scientific and socio-economic information on climate change and its impacts, and assesses options for mitigation and adaptation. To date, the IPCC has prepared comprehensive scientific reports on climate change on a regular basis. The First Assessment Report of the IPCC (published in 1990) indicated that levels of human-made GHGs were increasing in the atmosphere and predicted these would exacerbate global warming. It also illustrated the need for a political platform for countries to tackle the consequences of climate change, thereby playing a critical role in the creation of the UNFCCC. Both the Second (1995) and Third (2001) Assessment Reports implied stronger linkages between human activity and climate change, thereby strengthening efforts for the negotiation of the Kyoto Protocol. The Fourth (and latest) Assessment Report (2007) noted that the evidence for global warming is 'unequivocal' and forecasted warming of 1.8°C to 4.0°C by 2100. The IPCC is currently working on the Fifth Assessment Report, which is due to be released in 2014.

The regional development banks (such as the Asian Development Bank and the Inter-American Development Bank) are also key multilateral actors responding to climate change, launching their own initiatives. The European Investment Bank, which has a specific European Union member focus, has been a key player in supporting climate change responses through mitigation, adaptation, research, development and innovation, technology transfer, cooperation and support for carbon markets. The Organisation for Economic Co-operation and Development (OECD) has also been working on climate change issues for almost three decades, particularly on economic and policy analysis.

A number of **bilateral initiatives** to address climate change have emerged over the past few years. One of the largest funds of this type is Japan's 'Cool Earth Partnership', along with the UK's 'Environmental Transformation Fund – International Window' and Germany's 'International Climate Protection Initiative'. The European Union works on climate change issues mainly through its 'Global Climate Change Alliance'. While bilateral funds are actively supporting climate change responses in developing countries, most are considered to be part of donors' official development assistance and, in some cases, the funds are loans instead of grants.

Arrangements for climate change action have also been emerging at the **regional level**. One example is the 'Asia-Pacific Partnership on Clean Development and Climate', which is a partnership between seven major Asia-Pacific countries.

Another example of regional cooperation is the 'European Emissions Trading Scheme', which is the largest multinational GHG emissions trading scheme in the world, involving 25 countries. It is designed to assist countries to meet their emission reduction commitments under the Kyoto Protocol.

National level

National governments have the primary responsibility for signing international agreements, curbing GHG emissions and responding to climate-related disasters. Some countries, such as the US and China, have been relatively less supportive of international climate policies, but have established rather robust national climate change initiatives. Other countries, such as the UK and Germany, have been key promoters of climate policies and introduced an array of policies to achieve long-term reductions. However, national mitigation strategies as well as adaptation and disaster management plans often omit urban areas. Developing countries still lag behind developed countries in terms of climate change action although an increasing number are introducing national programmes of action in response to climate change.

State/provincial level

National governments are not able to meet their international commitments for addressing mitigation and adaptation without localized action. Already, sub-national governments at the state/provincial level are playing an increasingly important role in climate change mitigation and adaptation. Policy networks, political leaders and research groups have

The CDM offers significant potential for urban projects in such sectors as waste recycling

Box 4 Major international city networks and initiatives on climate change

- ICLEI-Local Governments for Sustainability;
- The Large Cities Climate Leadership Group, also known as the C40;
- The Clinton Climate Initiative;
- The World Mayors Council for Climate Change;
- United Cities and Local Governments;
- The Climate Alliance;
- The Asian Cities Climate Change Resilience Network;
- The Covenant of Mayors.

been critical in launching a climate agenda in their countries. However, in general, policy-making has been constrained by two sets of institutional factors: the problem of fragmentation in local governance and lack of institutional capacity.

Local/city level

Although the Kyoto Protocol does not explicitly identify a role for cities and local governments in responding to climate change, city-level actors are participating in climate strategies, projects and programmes. Cities are increasingly becoming involved in international city networks which represent a form of multilevel environmental governance across national boundaries and with the involvement of multiple governmental, private-sector, non-profit and other civil society stakeholders (see Box 4). National city networks have also been important in developing municipal capacity in countries where national governments have failed to take action. In general terms, most city networks have focused on climate change **mitigation**, although **adaptation** has been receiving greater attention in recent years.

However, networks have had an uneven impact, with evidence suggesting that they are more important in developing the capacity of those municipalities that are already leading responses to climate change, and that while the political support and knowledge transfer functions that such networks perform is valuable, their impacts can be limited in the absence of resources to implement programmes.

In addition to city authorities, individuals, households and community-based organizations as well as other local actors, have an important role to play in both international climate change negotiations and city-level mitigation and adaptation activities. The private sector also has an important role to play in efforts aimed at curbing GHG emissions, with a growing number of private-sector companies considering how to mitigate emissions through transforming their own work practices and playing a key role in defining investments in climate-proofing infrastructures, energy utilities, and other urban sectors. Indeed, urban capacity to address climate change is increasingly shaped by partnerships between public, private, and civil society actors.

THE POTENTIAL OF THE INTERNATIONAL CLIMATE CHANGE FRAMEWORK FOR LOCAL ACTION

A major factor constraining urban actors' use of mechanisms within the international climate change framework is the fact that these mechanisms are primarily addressed to national governments and do not indicate a clear process by which urban areas and actors may participate. Consequently, getting urban priorities moved up on national agendas can be problematic, at best.

A further major challenge for local authorities to take advantage of the international climate change framework to implement climate responses locally is that they are often overwhelmed by competing priorities. In addition, mismatches exist between climate and local policy-making timeframes. Given the fact that many of the cause and effect relationships are long term and potentially irreversible, they require planning that goes beyond the tenure, the administrative power and even the lifetime of most current decision-makers and other stakeholders.

CHAPTER 3

THE CONTRIBUTION OF URBAN AREAS TO CLIMATE CHANGE

There are several reasons why it is important to consider the contribution of urban areas to climate change. First, a range of activities that directly contribute to GHG emissions such as transportation, energy generation and industrial production are associated with cities and their functioning. Urban centres also rely on inward flows of food, water and consumer goods that may result in GHG emissions from areas outside the city. Second, measuring emissions from different cities provides a basis for comparisons and creates the potential for inter-urban competition and cooperation to reduce emissions. Third, an assessment of the contribution of cities to climate change is a vital first step in identifying potential solutions as well as correct allocation of responsibilities. Finally, and linked to issues of responsibility, it is important to highlight the differences between production- and consumption-based analyses of GHG emissions.

MEASURING GREENHOUSE GAS EMISSIONS

International protocols for measuring GHG emissions have been elaborated by IPCC. National inventories are prepared according to a detailed set of criteria developed by the IPCC. However, the IPCC methodology for countries does not provide specifications at the **local authority level** for measuring emissions.

A growing recognition of the importance of urban areas in both contributing to and mitigating GHG emissions has led to increasing attempts to develop appropriate inventories to account for city-level emissions. For instance, Local Governments for Sustainability (ICLEI) has developed a framework (*International Local Government GHG Emissions Analysis Protocol*) that provides the basis for the calculation of most current city-wide GHG emissions inventories. The recently launched *International Standard for Determining Greenhouse Gas Emissions for Cities* further provides a common method for cities to calculate the amount of GHG emissions produced within their boundaries.

As **industries and corporations** have also become increasingly aware of the impact that their activities have on the environment, they are conducting GHG inventories. The *Greenhouse Gas Protocol* provides a mechanism by which private-sector actors can contribute to the global goal of reducing GHG emissions.

However, existing methods of measuring GHG emissions have to grapple with complex issues of production- and consumption-based measures for allocating emissions. A more detailed consumption-based analysis requires much more information relating to the embedded carbon content of consumer goods purchased by individuals. The issue of delineating urban boundaries when making assessments is also problematic. Even within a single country, the potential contribution of urban areas to climate change can vary by a factor of two depending on the spatial definition of these areas.

Furthermore, patterns of urban consumption that drive emissions (notably in the energy and industry sectors)

The increased dependence on private motorized vehicles is a major source of urban GHG emissions

are often veiled. For example, many polluting and carbon-intensive manufacturing processes are no longer located in developed countries, but have been sited elsewhere to take advantage of lower labour costs and less rigorous environmental enforcement.

THE SOURCES OF GREENHOUSE GAS EMISSIONS

Different activities or sectors emit different quantities of different GHGs – with diverse resulting impacts on climate change. The main sources of GHG emissions from urban areas are related to the consumption of fossil fuels; whether this is for electricity supply, transportation or industry.

Energy supply is responsible for about 26 per cent of global GHG emissions. The combustion of fossil fuels is the major source of these, and is used throughout the world for electricity generation, heating, cooling, cooking, transportation and industrial production. Urban areas rely heavily on energy systems (shaped by the quantity of energy used), the energy structure (types of energy forms used) and the quality of the energy (its energetic and environmental characteristics). In countries relying heavily on coal for electricity generation, electricity can be the single largest contributor to GHG emissions. Cities relying on nuclear or hydroelectric power have been found to generate substantially lower emissions than those that depend primarily on coal-fired power stations, although large indirect emissions are associated with the mining (and refining) of uranium and the building of nuclear plants. A wide variety of renewable energy systems (such as solar, wind, wave, etc. – at different stages of maturity and development) can contribute to the security of energy supply and the reduction in GHG emissions.

Transportation is responsible for about 13 per cent of global GHG emissions. Urban areas rely heavily on transportation networks of various kinds for both internal and external movements of goods and people. The proportion of journeys made by private as opposed to public transportation – particularly in larger cities – is an important factor influencing GHG emissions from an urban area. Even when cars are chosen as the mode of transport, there are large variations in the GHG emissions produced by different sizes and types of vehicles.

The issue of emissions from transportation in developing countries is particularly important in countries

Urban consumption drives industrial development and related GHG emissions

where motor vehicle ownership is expanding rapidly. There are currently (2011) nearly 1.2 billion passenger vehicles worldwide. By 2050, this figure is projected to reach 2.6 billion – the majority of which will be found in developing countries. There is a strong association between rising income and car use in developing countries, meaning that economic growth in developing countries is likely to result in increased car use and rising traffic congestion.

The aviation industry, which accounts for about 2 per cent of total anthropogenic GHG emissions, is not included within a country's national GHG inventory. Globally, shipping is responsible for about 10 per cent of transportation energy use, but emissions from international maritime transportation are also not included within national GHG inventories.

GHG emissions from **commercial and residential buildings** are closely associated with emissions from electricity use, space heating and cooling. When combined, the IPCC estimates global emissions from residential and commercial buildings to be 8 per cent of global GHG emissions. Emissions are affected by the need for heating and cooling, and by the behaviour of building occupants. The type of fuel used for heating and cooling also determines the amount of GHGs emitted, as do overall patterns of residential density.

Globally, 19 per cent of GHG emissions are associated with **industry**. Many industrial activities are energy-intensive in their operation, in particular the manufacture of iron and steel, non-ferrous metals, chemicals and fertilizer, petroleum refining, cement, and pulp and paper. There are evident and wide-ranging differences in industrial emissions according to the location and size of the industry. In recent decades, the pattern of industrial activities has shifted, in part due to transnational corporations seeking lower wages and higher profitability, and in part due to the increasing success of companies and corporations from China, India, Brazil and elsewhere competing in the world market. Differences in environmental legislation have also transformed the geography of industrial location.

Emissions from **waste** represent about 3 per cent of total emissions. Despite being only a small contributor to global emissions, rates of waste generation have been increasing in recent years, particularly in developing countries that have experienced increasing affluence. Although waste generation is linked to population, affluence and urbanization, emissions from waste may be lower in more affluent cities, as urban areas have the potential to greatly reduce – or even eliminate – emissions from waste. Thus, the significant variations between countries in terms of emissions from waste

City	GHG emissions per capita (tonnes of CO_2eq) (year of study in brackets)	National emissions per capita (tonnes of CO_2eq) (year of study in brackets)
Washington, DC (US)	19.7 (2005)	23.9 (2004)
Glasgow (UK)	8.4 (2004)	11.2 (2004)
Toronto (Canada)	8.2 (2001)	23.7 (2004)
Shanghai (China)	8.1 (1998)	3.4 (1994)
New York City (US)	7.1 (2005)	23.9 (2004)
Beijing (China)	6.9 (1998)	3.4 (1994)
London (UK)	6.2 (2006)	11.2 (2004)
Tokyo (Japan)	4.8 (1998)	10.6 (2004)
Seoul (Republic of Korea)	3.8 (1998)	6.7 (1990)
Barcelona (Spain)	3.4 (1996)	10.0 (2004)
Rio de Janeiro (Brazil)	2.3 (1998)	8.2 (1994)
São Paulo (Brazil)	1.5 (2003)	8.2 (1994)

Source: Dodman, 2009

Table 2

Comparisons of city and national GHG emissions, selected cities

are due not only to different patterns of consumption and waste generation, but also to differences in the management of waste and differences in accounting mechanisms.

At a global level, 31 per cent of GHG emissions can be allocated to activities related to **agriculture and forestry**. Urban areas shape emissions from agriculture, land-use change and forestry in two major ways. First, the process of urbanization can involve direct changes in land-use, as formerly agricultural land becomes incorporated within built-up areas. Indeed, global urban trends towards sub-urbanization mean that cities are continuing to sprawl and encroach on land that may previously have been covered with vegetation – thereby reducing its potential to absorb CO_2. Second, the consumption patterns of increasingly wealthy urban residents can shape the type of agricultural activities undertaken. To meet their consumption needs, city-based enterprises, households and institutions place significant demands on forests, farmlands and watersheds outside urban boundaries.

THE SCALE OF URBAN AND NATIONAL EMISSIONS

It is impossible to make definitive statements about the scale of urban emissions as there is no globally accepted standard for assessing their scope and most urban centres have not attempted to conduct an inventory of this type.

The economic activities, behavioural patterns and GHG emissions from urban areas are shaped by the overall economic, political and social circumstances of the countries in which they are located. At a global level, there are striking differences in GHG emissions between regions and countries. The 18 per cent of the world's population living in developed countries account for 47 per cent of global CO_2 emissions, while the 82 per cent of the world's population living in developing countries account for the remaining 53 per cent (see also Figure 2).

Global growth in GHG emissions has not therefore been distributed evenly between countries, and many of the countries with very low emissions currently are not experiencing rapid increases in emissions. However, if they experience rapid economic growth, this situation may change. A striking aspect of emissions inventories is that average per capita emissions for many large cities are substantially lower than for the country in which they are located (see Table 2). Evidently, for a given level of economic development, urban areas offer the opportunity to support lifestyles that generate smaller quantities of GHG emissions.

Urban emissions in developed countries

Since the middle of the 20th century, urban economies in developed countries have shifted away from secondary industry into tertiary and quaternary industries. This means that their emissions from the manufacture of products are relatively low. At the same time, these urban areas have become centres of wealth and consumption. The lifestyles of their residents – particularly related to consumption and

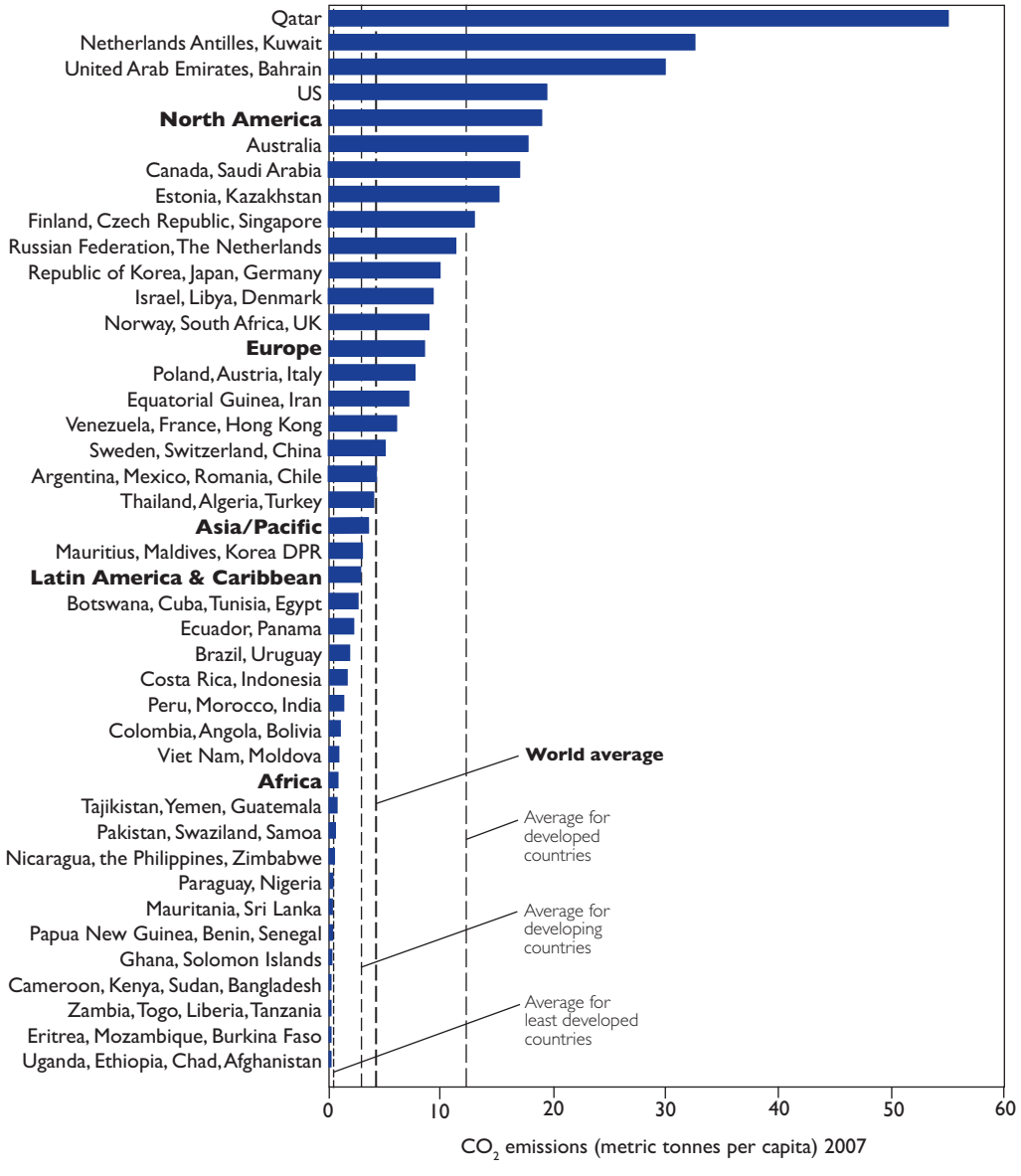

Figure 2

CO_2 emissions per capita in selected countries and world regions (2007)

travel – generate a large carbon footprint, yet this is seldom accounted for in emissions inventories.

In comparison to North American cities, the contribution of urban areas in Europe to climate change is relatively low. This is as a result of several factors: European urban areas tend to be more compact. They also tend to have lower car ownership and car usage rates, and smaller, more fuel-efficient cars, thus reducing emissions from private transportation. They also tend to have more effective public transportation networks, which are deemed socially acceptable to a broader range of individuals.

Urban emissions in developing countries

Very few detailed emissions inventories have been produced by cities in developing countries. Cities in these countries are frequently economic centres that contribute significantly to the gross national product, and act as economic, political, social and cultural centres. Consequently, they are centres of consumption and wealth and are likely to have higher per capita GHG emissions than surrounding areas.

While manufacturing has declined in importance in developed countries, it has expanded rapidly in some developing countries. Countries such as Brazil, China, India and South Africa – encouraged by economic and geopolitical changes – are now centres for global manufacturing and, are thus, playing an increasingly important role in contributing to global GHG emissions.

China has recently overtaken the US as the world's leading total emitter of GHGs, although its per capita emissions are significantly lower. Brazil, China, India and South Africa – although not part of the legally binding framework to reduce emissions – recognize that their substantial emissions compel them to take a more progressive role in international climate negotiations.

The responsibility for urban emissions is clearly not distributed evenly throughout the urban population, especially in highly unequal societies. A significant proportion of urban residents in the least developed and other low-income countries have very low levels of GHG emissions because of their limited use of fossil fuels and electricity, and consumption of goods and services that require GHG emissions for their production and transportation.

Estimating the global level of urban emissions

Any blanket statements about the total contribution of urban areas or cities to GHG emissions need to be treated with caution. There is no globally accepted definition of an urban area or city, and there are no globally accepted standards for recording emissions from sub-national areas. In addition, there is little clarity on the relative allocation of responsibility from production- or consumption-based approaches and therefore 'drawing the line' as to exactly how urban areas 'contribute' to climate change can be a highly subjective process.

Nevertheless, some experts have suggested that the proportion of anthropogenic GHG emissions resulting from cities using production-based figures could be between 40–70 per cent of the total, while a consumption-based calculation suggests levels as high as 60–70 per cent.

FACTORS INFLUENCING EMISSIONS

As the previous section showed, the contribution of urban areas to GHG emissions in different countries – and even of different urban areas within the same country – varies greatly. This is due to a variety of interrelated factors, including differences in the sources of emissions.

Geographic situation

Various aspects of geography affect the contribution of urban areas to climate change. These can be broadly categorized as climatic situation, altitude and location in relation to natural resources. The climatic situation of any given urban area affects the energy demands for heating and cooling. The geographical location in relation to natural resources influences the fuels that are used for energy generation, and hence the levels of GHG emissions.

The potential for using renewable sources of energy – and the reductions in GHG emissions associated with this – are also affected by locational factors. Some renewable energy is entirely reliant on natural resources. For example, the availability of large rivers is necessary for hydroelectric generation. Wind, geothermal, tidal and wave energy all also rely on natural resources existing in particular locations.

Demographic situation

The relationship between population growth and GHG emissions is complicated, and varies according to the level of analysis. The wide variations in national GHG emissions (see Figure 2) indicate that population size in itself is not a major driver of global warming. At a global level, the areas experiencing the highest rates of population growth are areas with currently low levels of per capita emissions. Equally, developing countries have lower rates of growth of CO_2 emissions compared with developed countries that have much lower rates of population growth.

The demographic composition of a society has a wide range of effects on consumption behaviour and GHG emissions. In some urban areas, changing age structures will affect GHG emissions associated with energy use. The demographic trend towards smaller households also offers reduced economies of scale with the result that the per capita energy consumption of smaller households is significantly higher than that of larger households. Paradoxically, the slowing of population growth may result in increased emissions, as lower population growth and smaller

households sizes may be associated with a rise in the number of separate households and increased disposable income to be spent on consumption.

Taking this into account, it is not the absolute number of people who live in urban areas that affects the contribution of these areas to climate change. Rather, it is the way in which these areas are managed, and the choices that are made by the urban residents living there that have the greatest effects.

Urban form and density

Urban form and density are associated with a range of social and environmental consequences. On one hand, the extremely high densities of many cities in developing countries – particularly in informal settlements and other slums – result in increased health risks, and high levels of vulnerability to climate change and extreme events. At the other extreme, the low densities of many suburban areas in North America are associated with high levels of household energy consumption as a result of urban sprawl and extensive car usage.

There is strong evidence that, globally, urban densities have generally been declining over the past two centuries. The reduction in urban densities is likely to continue into the future. It is estimated that the total population of cities in developing countries will double between 2000 and 2030, while the size of the built-up areas will triple.

Urban form and urban spatial organization can have a wide variety of implications for a city's GHG emissions. The high concentrations of people and economic activities in urban areas can lead to economies of scale, proximity and agglomeration – all of which can have a positive impact on energy use and associated emissions.

Density may also affect household energy consumption, as more compact housing uses less energy for heating. Dense urban settlements can therefore be seen to enable lifestyles that reduce per capita GHG emissions through the concentration of services that reduces the need to travel long distances, the better provision of public transportation networks, and the constraints on the size of residential dwellings imposed by the scarcity and high cost of land.

The urban economy

The types of economic activities that take place within urban areas directly influence GHG emissions. All urban areas rely on a wide range of manufactured goods (produced within the urban area or elsewhere), and manufacturing areas similarly rely on the services provided by certain urban centres. Many of the world's cities today act as centres for the trading of commodities and consumption of manufactured goods, while generating few emissions from within their own boundaries.

Air conditioning for urban buildings drives energy consumption upwards

The politics of measuring emissions

Consequently, there are striking differences in the contribution of different urban areas to climate change. Measured purely in terms of direct emissions per person from a given urban area, these may vary by a factor of 100 or more. The per capita emissions of GHGs by individuals, including those caused by the goods they consume and wastes they generate vary by a dramatically high factor of more than 1000, depending on the circumstances into which they were born and their life chances and personal choices. The difference of measuring emissions through the production or consumption lens has, not surprisingly, been politicized in the debate around urban emissions measurement.

As noted earlier, urban areas in different countries, and even within the same country, have different emissions profiles according to environmental, economic, social, political and legal differences over space and across national boundaries. Political forces and the policy environment – at the global, national and local levels – are clearly a strong underlying factor in shaping GHG emissions. With so much at stake, the politics around the measurement of emissions turn on whether an ecological footprints methodology is used in stead of carbon footprints; whether the previously mentioned production-based versus consumption-based approaches are used; and whether production and consumption patterns of the individual is given prominence as opposed to structural and contextual 'drivers' of emissions in urban areas.

CHAPTER 4

THE IMPACTS OF CLIMATE CHANGE ON URBAN AREAS

With increasing urbanization, understanding the impacts of climate change on urban areas will become ever more important. Evidence is mounting that climate change presents unique challenges for urban areas and their growing populations. Where urban areas grow rapidly without regard to current and future resource demands and future impacts of climate change, large numbers of people and their assets can find themselves vulnerable to a range of disruptive and damaging risks.

These impacts extend far beyond the physical risks posed by climate change such as sea-level rise and extreme weather events. Cities could face difficulties in providing even the most basic services to their inhabitants as a result of climate change. Climate change may affect water supply, ecosystem goods and services, energy provision, industry and services in cities around the world. It can disrupt local economies and strip populations of their assets and livelihoods, in some cases leading to mass migration. Such impacts are unlikely to be evenly spread among regions and cities, across sectors of the economy or among socio-economic groups. Instead, impacts tend to reinforce existing inequalities and, as a result, climate change can disrupt the social fabric of cities and exacerbate poverty.

CLIMATE CHANGE RISKS FACING URBAN AREAS

Atmospheric and oceanic warming as a result of human activities has been observed over the past several decades leading to changes in precipitation frequency and intensity, cyclone activity, glacial melt and sea-level rise. These physical changes, and the associated responses of ecosystems and economies, have discernible implications for cities worldwide, although characterized by wide geographical variation. Many of these changes are manifesting themselves as a gradual building of climate impacts and are already becoming a reality. However, the possible effects of abrupt climate change events have not yet been fully explored (see Table 3).

Average **sea levels** have been rising around the world during recent decades but with significant regional variation. Thermal expansion, or the increase of ocean water in volume as it warms, is considered to be the leading cause of sea-level rise, but melting ice sheets may become more important in the future. There may be temperature thresholds or 'tipping points' that accelerate melting to rates not yet experienced in modern times.

Tropical cyclones are weather systems associated with thunderstorms and strong winds that are characterized by their wind circulation patterns around a well-defined centre. Globally, tropical cyclones and extra-tropical storms have been increasing in intensity since the 1970s as measured by their wind speed and other indices of a storm's destructive power. With global warming, potential intensity is predicted to increase in most regions of tropical cyclone activity.

On average, observations indicate that heavy one-day and heavy multi-day precipitation events have increased globally throughout the 20th century and these trends are very likely to continue in the 21st century. More frequent

Climate phenomena	Likelihood	Major projected impacts
Fewer cold days and nights	Virtually certain	Reduced energy demand for heating
Warmer and more frequent hot days and nights over most land areas	Virtually certain	Increased demand for cooling
Warmer temperatures	Virtually certain	Reduced disruption to transport due to snow, and ice effects on winter tourism Changes in permafrost, damage to buildings and infrastructures
Warm spells/heat waves: frequency increases over most land areas	Very likely	Reduction in quality of life for people in warm areas without air conditioning; impacts on elderly, very young and poor, including significant loss of human life Increases in energy usage for air conditioning
Heavy precipitation events: frequency increases over most areas	Very likely	Disruption of settlements, commerce, transport and societies due to flooding Significant loss of human life, injuries; loss of, and damage to, property and infrastructure Potential for use of rainwater in hydropower generation increased in many areas
Areas affected by drought increase	Likely	Water shortages for households, industries and services Reduced hydropower generation potentials Potential for population migration
Intense tropical cyclone activity increases	Likely	Disruption of settlements by flood and high winds Disruption of public water supply Withdrawal of risk coverage in vulnerable areas by private insurers (at least in developed countries) Significant loss of human life, injuries; loss of, and damage to, property Potential for population migration
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	Costs of coastal protection and costs of land-use relocation increase Decreased freshwater availability due to saltwater intrusion Significant loss of human life, injuries; loss of, and damage to, property and infrastructure Potential for movement of population

Table 3

Projected impacts on urban areas of changes in extreme weather and climate events

heavy precipitation events will have far-reaching economic and social implications for the urban environment especially through flooding and landslides. Indeed, floods are among the most costly and damaging disasters and their frequency and severity has generally increased in the last decade.

As a result of climate change, **extreme heat events** are predicted to become more frequent, intense and longer lasting over most land areas. There is, however, no standard definition of an extreme heat event or heat wave due to the importance of local acclimatization to climate, which varies geographically. Extreme events are exacerbated in cities by the urban heat-island effect – the tendency of cities to retain heat more than their surrounding rural areas. For the average developed country city of 1 million people, this phenomenon can cause air temperatures that are 1–3°C higher than the city's surrounding area.

Not only have **droughts** become more common in the tropics and subtropics since 1970 but, more likely than not, humans have contributed to this trend. Currently, as much as 1 per cent of all land area is considered as being under extreme drought conditions. By 2100, this could increase to as much as 30 per cent. Water stress is likely to increase as a result of changes in precipitation, the consequent decline in water supply and quality, as well as increased demand for water.

IMPACTS ON PHYSICAL INFRASTRUCTURE

Climate change has direct effects on the physical infrastructure of a city – its network of buildings, roads, drainage and energy systems – which in turn impact the welfare and livelihoods of its residents. These impacts will be particularly severe in low-elevation coastal zones where many of the world's largest cities are located. Although they account for only 2 per cent of the world's total land area, approximately 13 per cent of the world's urban population lives in these zones.

Substantial damage to **residential and commercial structures** is expected with the increasing occurrence of climate change-related hazards and disasters. In this regard, flooding is one of the most costly and destructive natural

Sea-level rise is a serious concern for coastal cities

hazards, and one that is likely to increase in many regions of the world as precipitation intensity increases. In addition, coastal erosion and saltwater intrusion can ruin buildings and render some areas uninhabitable. Subsidence, or the downward shift of the Earth's surface, is another 'slow-onset' factor that poses a risk to residential and commercial structures in cities. Subsidence can be as rapid as 1m per decade, resulting in significant damage to pipelines, building foundations and other infrastructure.

Climate change impacts frequently disrupt **transportation systems** through weather conditions that have immediate impacts on travel and damages that cause lasting service interruptions. In coastal cities in particular, sea-level rise can inundate highways and cause erosion of road bases and bridge supports. Heavy precipitation and its effects in the form of flooding and landslides can cause lasting damage to transportation infrastructure such as highways, seaports, bridges and airport runways. Higher temperatures, in particular long periods of drought and higher daily temperatures, compromise the integrity of paved roadways and necessitate more frequent repairs. Besides potentially endangering lives, the destruction or damage of transportation systems and prolonged service disruptions greatly impact nearly all aspects of urban life.

By their very nature, cities are centres of high demand for **energy** and related resources. Climate change is likely to impact both energy demand and supply. The combination of urban population growth, changing local weather conditions, urban heat-island impacts and economic growth has the potential to substantially increase demand for energy. Climate change will also affect energy generation and distribution. For instance, electricity transmission infrastructure may become increasingly vulnerable to damage and interference as storms and flooding become more frequent and intense.

The availability, treatment and distribution of water could be impacted by climate change as temperatures increase and precipitation patterns change: on the one hand, climate change is expected to compromise **water supplies**, through changes in precipitation patterns, reductions in river flows, falling groundwater tables and, in coastal areas, saline intrusion in rivers and groundwater. On the other hand, with rising temperatures, more frequent extreme heat events and population growth in the future, demand for water in cities is expected to increase. Climate change-related changes in precipitation and sea levels can also affect the quality and treatment of water in cities.

Climate change-related disasters may also affect **sanitation systems** in urban areas which already face serious challenges, especially in developing countries.

The impacts of flooding are expected to worsen with climate change

ECONOMIC IMPACTS

The increasing frequency and intensity of extreme climatic events and slow-onset changes will increase the vulnerability of urban economic assets and subsequently the cost of doing business. Climate change will impact a broad range of **economic activities** including trade, manufacturing, tourism and the insurance industry.

The direct effects of climate change and extreme climate events on industry include damage to buildings, infrastructure and other assets. These effects are especially severe where industrial facilities are located in vulnerable areas such as coastal zones and floodplains. The indirect impacts of climate change on industry include those resulting from delays and cancellations due to climate impacts on transportation, communications and power infrastructure. Similarly, retail and commercial services are vulnerable because of supply chain, network and transportation disruptions, as well as changes in consumption patterns.

The tourism industry, and associated services, is highly dependent upon reliable transportation infrastructure including airports, ports and roadways. Climate change has the potential to shift regional temperature distributions, consequently transforming season-related recreational opportunities and tourism infrastructure. Severe weather events and related transportation delays and cancellations may also negatively impact tourism. Local urban economies could incur significant monetary and job losses since recreational activities and tourism are often major sources of revenue for urban areas.

The insurance industry is also vulnerable to climate change, particularly extreme climate events that impact a large area. Climate change could result in increasing demand for insurance while reducing insurability. The costs of insurance coverage are expected to increase significantly if infrequent but catastrophic events become more common in the future. The uncertainty surrounding the probability of high-loss events in the future is likely to place upward pressure on insurance premiums.

Climate change has been identified as a key factor behind the accelerated loss and degradation of **ecosystem services**. Ecosystem services include oxygen production, carbon storage, natural filtering of toxins and pollutants, and protection of coastal societies from flooding and wind during storms. Human activities (e.g. development, pollution, wetland destruction) can harm such ecosystem services. Increasing urbanization places greater demand on natural resources and imposes significant changes on the environ-

Poor women and children are especially vulnerable to natural disaster impacts

mental processes that drive the benefits that societies derive from ecosystem services.

Climate change-related disasters destroy livelihood assets and thereby directly affect **urban livelihoods**. These include stocks of natural resources (natural capital), social relationships (socio-political capital), skills and health (human capital), infrastructure (physical capital) and financial resources (financial capital). Livelihood impacts will also vary from one context to another depending on the vulnerability of existing assets and opportunities. For instance, the livelihoods of the urban poor are likely to be most at risk from climate change effects since their assets and livelihoods are already meagre and unreliable. Livelihood activities of the urban poor are also more impacted by climate events than other social groups because of their presence in at-risk zones such as informal settlements in flood-prone areas.

PUBLIC HEALTH IMPACTS

Climate changes cause local weather conditions – including extreme heat and severe weather events – that impact public health in urban areas. Poverty acts as a compounding factor which exacerbates the health impacts of climate change. With more individuals moving to urban locations, higher temperatures, and a rapidly aging society, the threat of heat-related mortality will become more severe in future. Death from heat is already significantly underreported.

Catastrophic events have both immediate and lasting impacts on public health. Beyond causing immediate death and injuries, floods and storms can cause long-term damage to facilities that provide health-related services. Power outages can disrupt hospital services. Likewise, clean water provision can be compromised if treatment facilities are structurally damaged or lack power.

Physical climate changes including temperature, precipitation, humidity and sea-level rise can alter the range, life cycle and rate of transmission of certain infectious diseases. Flooding can introduce contaminants and diseases into water supplies and can increase the incidence of diarrhoeal and respiratory illnesses in both developed and developing countries.

SOCIAL IMPACTS

Climate change differentially impacts groups of individuals, such as marginalized minorities, women and men, young and old. Individuals, households and communities that fall into more than one category of vulnerability can find the deck

Box 5 Poverty and climate change impacts in cities

Within any urban centre, it is common for poorer groups to be disproportionately at risk for a variety of reasons, including:

- greater exposure to hazards (e.g. through living on flood plains or unstable slopes);
- lack of risk-reducing housing and infrastructure (e.g. poor-quality housing, lack of drainage systems);
- less adaptive capacity (e.g. lacking the income or assets that allow a move to better quality housing or less dangerous sites);
- less state provision for assistance in the event of a disaster (e.g. needed emergency responses and support for rebuilding or repairing homes and livelihoods; indeed, state action may increase exposure to hazards by limiting access to safe sites for housing); and
- less legal and financial protection (e.g. a lack of legal tenure for housing sites, lack of insurance and disaster-proof assets).

dramatically stacked against them in terms of their ability to prepare for, and respond to, the varied impacts they already face and that they will face in the future. Climate change impacts magnify gender and racial inequalities, often impacting poor minorities and poor women more than other groups. A vicious cycle then develops whereby marginalized groups bear the greatest burdens of climate change, thus preventing them from escaping poverty and leaving them continuously vulnerable to further change.

Climate change is considered as a distributional phenomenon because it differentially impacts individuals and groups based on wealth and access to resources. In general, low-income households in both developed and developing countries are most vulnerable to climate change impacts primarily due to the scale and nature of the assets they possess or can draw on, as illustrated in Box 5.

Studies of disaster impacts from extreme weather events in urban areas suggest the majority of those who are killed or seriously injured and that lose most, or all, of their assets are from low-income groups. In the event of a natural disaster, low-income households often lack the resources to mitigate resulting damage through healthcare, structural repair, communication, food and water. In the absence of adequate recovery assistance, the poor often sacrifice their family's nutrition, children's education, or any remaining assets to meet their basic needs, thereby further limiting their chance of recovery and escape from poverty.

DISPLACEMENT AND FORCED MIGRATION

As the world's climate changes, resulting environmental degradation, drought and sea-level rise may lead to the permanent displacement of people and, consequently, increased internal and international migration. In 2008, an estimated 20 million individuals were displaced due to sudden-onset natural disasters alone. Projections for future climate change-related displacement average 200 million migrants by 2050.

Populations located at low elevations are especially vulnerable and inhabitants of some small island states located entirely below 3m or 4m above sea level may have to relocate entirely as sea-level rise and coastal subsidence continue.

While sudden disasters often force people to move quickly to a safe location, the poor often lack the resources to move and loss of assets during a disaster may only make it less likely that low-income households can relocate.

Depending on the scale and nature of these events, migration can result in social disruption or conflict, especially if migratory events bring into contact peoples with pre-existing social or cultural tensions. Also, new arrivals to cities may be seen as competitors for jobs or resources, generating distrust and possibly leading to conflict with existing urban populations.

IDENTIFYING CITIES VULNERABLE TO CLIMATE CHANGE

The concept of vulnerability in relation to climate change is also applicable to larger systems such as cities, or city-regions or to resources and ecosystem services.

As mentioned above, levels of **urbanization** are increasing worldwide. Rates of urbanization are higher in developing countries, which are less prepared than developed countries to deal with the resulting impacts. For these regions of the world, population growth can act as an acute threat multiplier and significantly exacerbate climate change impacts.

Increasing population means greater demand for resources – including energy, food and water – and greater volumes of waste products. Thus, urbanization can be a

significant vulnerability factor where demand for housing, infrastructure and services can grow much faster than supply. This in turn can force development in hazardous areas or with inadequate construction materials and techniques.

Risk is skewed toward developing countries such that more people are at risk of being impacted by a natural disaster in a developing country compared to a similar disaster in a developed country. Lack of **economic strength**, as is the case in many developing country cities, exacerbates vulnerability, by limiting the ability to minimize and adapt to the impacts of climate-related hazards. Those cities with greater income inequality and large populations of residents living in poverty have inherently high vulnerability.

Furthermore, developing country cities often lack risk management plans, early warning systems and the ability or foresight to move residents to safer locations when disasters are inevitable. Their local authorities do not have the capacity to respond to natural disasters, and if laws or plans do exist for disaster response, they are rendered ineffective from lack of human or financial capital to enact them.

The level of vulnerability of an urban area to climate change risks depends in part on how much of the city's population and economic assets are located in high-risk areas (i.e. **physical exposure**). Coastal cities in low-elevation coastal zones have high levels of exposure (in terms of population and assets) to sea-level rise, storm surges and flooding simply as a function of being so near the ocean.

Exposure can also be linked to land-use planning within the city, including continued development in known hazardous zones, as well as the destruction of natural protective areas. Coastal communities that encroach onto wetlands, sand dunes and forested areas, for instance, increase the likelihood of flooding, together with all its associated impacts. Disaster risk is often high for slums because construction occurs in particularly hazardous areas including steep slopes or in floodplains.

Weak structural defence mechanisms and oversight of building codes further increase the vulnerability of cities in high-risk areas. In particular, the substandard quality of housing and physical structures in slums increases the exposure of residents to climate change impacts.

Urban governance and planning can improve resilience to climate change impacts through targeted financing of adaptation, broad institutional strengthening, and minimizing the drivers of vulnerability. Urban areas with weak governance systems – as a result of political instability, exclusion of climate change from the political agenda, or lack of governmental resources – are especially vulnerable to climate change impacts.

The urban poor in both developing and developed countries cannot afford insurance cover

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In many cities throughout developing countries, populations continue to grow in the absence of effective urban planning, resulting in living conditions that exacerbate climate change impacts and development in areas at risk from sea-level rise, flooding and coastal storms. Similarly, weak building codes and standards (or lack of enforcement) increase the vulnerability of individual households and entire communities.

As climate change continues to occur, disasters such as landslides, floods, windstorms and extreme temperatures may occur with greater frequency and intensity. Urban vulnerability to climate change will therefore depend upon its disaster preparedness. **Disaster preparedness** may therefore be linked to governance and institutional capacity and the availability of information to residents, although it is not necessarily the case that poorer countries or cities will always be less prepared.

CHAPTER 5

CLIMATE CHANGE MITIGATION RESPONSES IN URBAN AREAS

Mitigation – the reduction of GHG emissions and their capture and storage – has been at the heart of policy responses to climate change over the past two decades. At the international level, the UNFCCC has as its core objective the 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. Cities can be seen as part of the problem of climate change and therefore critical places for achieving mitigation. However, cities can also be seen as part of the solution to addressing climate change (see Table 4).

Reducing GHG emissions in cities is a key policy challenge. Municipal authorities are important actors in tackling the challenge of mitigation for three reasons. First, they have jurisdictional responsibility for key processes which shape emissions. Second, the concentration of people and business in urban areas means that mitigation solutions are feasible. Third, municipal governments provide a key interface for engagement with private-sector and civil society stakeholders that also have a significant role in addressing climate change at the urban level.

During the 2000s, the cities involved in responding to climate change have grown in number and now include cities in the developing world, in part facilitated by the emergence of new international initiatives such as the C40 as well as the continuing work of more established networks (see Box 4).

Part of the problem	Part of the solution
• In 2010, half of the world's population lived in cities. • Between 2010 and 2020, 95% of the global population growth (766 million) will be urban residents (690 million), and the bulk of these (632 million) will be added to the urban population of developing countries. • Between 2000 and 2010, the number of slum dwellers in developing countries increased from 767 million to 828 million. The figure might reach 889 million by 2020. • Cities represent concentrations of economic and social activities that produce GHG emissions. • Cities and towns produce between 40 and 70 per cent of global anthropogenic GHG emissions. • By 2030 over 80 per cent of the increase in global annual energy demand above 2006 levels will come from cities in developing countries.	• Municipal authorities have responsibility for many processes that affect GHG emissions at the local level. • Municipalities can act as a 'laboratory' for testing innovative approaches. • Municipal authorities can act in partnership with private-sector and civil society actors. • Cities represent high concentrations of private-sector actors with growing commitment to act on climate change. • Cities provide arenas within which civil society is mobilizing to address climate change.

Table 4

Cities and the mitigation of climate change

Yet, the response of cities to the challenges of mitigation has been fragmented, and significant gaps exist between the rhetoric of addressing climate change and the realities of action on the ground.

The levels of GHG emissions from poor urban populations remain negligible, suggesting that urban efforts to mitigate climate change need to be targeted at cities where there is both a responsibility and a capacity to act. Furthermore, climate change will deepen a range of existing inequalities; thus, discussions of climate change mitigation in cities need to include broader concerns about the vulnerability of different social groups.

RESPONSES TO CLIMATE CHANGE MITIGATION IN URBAN AREAS

Over the past two decades, municipal authorities, as well as a range of other actors, have engaged in the development of urban climate change policies as well as initiatives and schemes to reduce GHG emissions in the city.

Municipalities have undertaken ad hoc measures to reduce GHG emissions from their own operations, often on a reactive basis – for example, in response to a particular funding opportunity or the initiative of an individual. They have also been developing one-off schemes or projects at the community scale. Strategic approaches, in contrast, have usually been developed where there has been access to secure funding, new institutional structures such as a central unit for addressing climate change and strong political support for action.

There are five key sectors in which urban responses to mitigating climate change have been concentrated, i.e. in: urban development and design; the built environment; in urban infrastructures; transport; and carbon sequestration.

Urban development and design

The use of energy within a city, and the associated GHG emissions, is dependent on both the form of urban development, i.e. its location and density, and also its design. In this respect, the twin challenges of urban sprawl and the growth of informal urban settlements are especially problematic. In seeking to address these challenges, various strategies of land-use planning, including land-use zoning, master-planning, urban densification, mixed-use development and urban design standards have been used to limit urban expansion, reduce the need to travel and increase the energy efficiency of the urban built form.

Enforcing emission regulations remains a key challenge in most cities

The confluence of a variety of interests and material circumstances in initiatives to mitigate climate change through urban design and development makes them complex and difficult to manage. For example, the development and implementation of 'low-carbon' planning principles by municipal governments may encounter political opposition, lack enforceability, and have limited impacts on the behaviour of individuals. It may also be socially divisive, reinforcing patterns of inequality in the city by creating enclaves of 'sustainable' living while failing to address the basic needs of the majority of urban citizens.

Renewable energy systems can contribute to reduction in GHG emissions

Built environment

The design and use of the built environment is a critical arena for climate change mitigation because in most countries the building sector consumes approximately one third of the final energy used, while absorbing an even more significant share of electricity.

Despite the potential range of initiatives that could be undertaken, measures in the built environment sector tend to focus on energy-efficient technologies, alternative energy supply technologies and demand-reduction practices. Furthermore, initiatives in the built environment sector have primarily been located in cities in developed countries.

In developing countries, initiatives have been established to install energy-efficient appliances in municipal buildings in several cities. In addition, the use of energy-efficient materials has been an important means through which municipal governments and other actors have sought to address GHG emissions reductions and the provision of low-cost housing to low-income groups.

Although energy efficiency measures related to the built environment can generate a variety of social and environmental benefits they could result in a 'rebound effect', that is, the tendency to use efficiency gains to increase consumption. Thus, energy efficiency measures need to be coupled with measures to develop low-carbon renewable energy sources and the reduction of energy demand.

Urban infrastructure

Urban infrastructure – in particular energy (electricity and gas) networks, and water and sanitation systems – is critical in shaping the current and future trajectories of GHG emissions. The type of energy supply, the carbon intensity of providing water, sanitation and waste services, and the release of methane from landfill sites are important components of GHG emissions at the local level.

Mitigating climate change is becoming an important issue in relation to urban infrastructures, but one that competes for attention with other pressures for energy security and affordability, and the provision of basic services. Nonetheless, municipal authorities and other government, private and civil society actors have undertaken a range of schemes in order to reduce GHG emissions through the refurbishment and development of urban infrastructure systems.

Initiatives to explicitly address climate change have been concentrated in the energy and energy-from-waste

Compact city development can help minimize energy consumption related to sprawl

domains and on the provision of new forms of energy supply. Fewer projects or plans have been initiated to address the carbon intensity of the provision of water, sanitation and waste services, or to reduce demand. Outside of the energy sector, there is relatively little evidence that municipalities are linking policies for recycling and reducing waste directly to climate change, while initiatives which specifically aim to reduce the carbon intensity of water and sanitation systems at the urban level are also rare.

Three different approaches for developing low-carbon forms of urban energy supply can be identified. First, many municipalities have sought to reduce the carbon footprint of existing supply networks. A second approach has been for municipalities to purchase renewable energy, either for their own buildings and operations, or as a means of offering consumers access to green energy at a reduced cost. A third approach has been to develop new low-carbon and renewable energy systems within cities. However, beyond small-scale demonstration projects, the development of low-carbon energy systems remains a low priority in most cities.

Nevertheless, there remain substantial barriers to the realization of mitigation gains in urban infrastructure in terms of the economics and politics of renovating existing infrastructure systems and building new networks, while meeting the basic needs of urban communities, particularly those in informal settlements. Also, few of these projects address social inclusion issues explicitly, nor do they specifically target low-income groups, disadvantaged areas or slums.

Transport

A recent survey of climate change plans in 30 cities worldwide found that the most common climate change mitigation actions in transport were the development of public transport (including bus rapid transit systems), the implementation of cleaner technologies, promotion of non-motorized transport, public awareness campaigns and implementation of cleaner technologies. Significantly, cities are also providing arenas for the experimentation and promotion of new technologies, such as in the cases of compressed natural gas use in transport in several cities around the world including Tehran (Iran), Mumbai (India), Dhaka (Bangladesh) and Bogotá (Colombia), while in Brazil biofuels are promoted in the country's megacities.

Regulatory measures to promote energy-efficient vehicles can reduce emissions

Carbon sequestration

Carbon sequestration involves removing GHG emissions from the atmosphere, either through enhancing natural 'carbon sinks' (e.g. conserving forested areas and enhancing river environments), the development of new carbon sinks (e.g. reforestation or afforestation) or through the capture and storage of GHGs being produced within the city (e.g. the capture of methane from landfill sites for energy generation).

Regionally, carbon sequestration schemes are more common in developing country cities, often associated with gaining CDM credits or development programmes. However, actions promoting urban tree-planting and restoration, preservation or conservation of carbon sinks may be taken in cities in developed countries for reasons of environmental protection or the preservation of urban green spaces without associating them specifically with climate change mitigation objectives.

Urban carbon sequestration in most cities generally remains at an incipient stage. The technology to facilitate carbon capture and storage is still under development, and proposals for its implementation in cities are only now emerging. Carbon offset schemes based at the city level are also rare, and often reach beyond city limits. Currently most carbon sequestration initiatives at the urban level relate to tree-planting schemes, and the restoration and preservation of carbon sinks.

Assessing the impact of urban climate change mitigation initiatives

There is relatively limited information about the individual and collective impact of current mitigation measures, especially when they extend beyond municipal buildings and infrastructure systems or involve behavioural change.

However, it is clear that systematic efforts to shift from fossil fuel-based energy and transport systems through the use of low-carbon technologies are likely to have a more significant impact on reducing GHG emissions than small-scale, short-term initiatives to improve energy efficiency.

Decisions over which mitigation measures to adopt will be determined by the social, political and economic circumstances of individual cities, and guided by the weight given to climate change concerns, rather than by any absolute evaluation of their effectiveness. The reality is that there are multiple drivers and barriers to achieving climate change mitigation in the city.

URBAN GOVERNANCE FOR CLIMATE CHANGE MITIGATION

Research has shown that a small number of distinct 'modes of governing' by municipalities are being employed to address climate change in the urban arena. In terms of the modes of governing deployed by municipal authorities, the approaches used appear to fall into four categories. These can be defined as: self-governing, provision, regulation and enabling.

These four approaches are not mutually exclusive; rather municipalities tend to deploy a combination of these modes at any one time. Nevertheless, the self-governing mode remains the dominant approach adopted by municipal authorities in response to climate change.

Given the cross-cutting nature of climate change as a policy issue, it is perhaps not surprising to find that there is no single 'recipe for success' – leading to a 'patchwork' of approaches being adopted.

In the **self-governing** mode, there are three principal means through which municipal authorities have sought to reduce their own GHG emissions. The first is through the management of municipal buildings, fleets and services. The second is through procurement policies, including purchasing renewable energy for the municipality, or in the transport sector, buying alternative low-carbon fuels. Third, local authorities may aim to lead by example, establishing best practice principles, or demonstrate the use of particular technologies or social practices to facilitate their widespread adoption by other local actors.

The effectiveness of self-governing measures in reducing urban GHG emissions is limited by the extent of the municipal estate and operations. Also, in the majority of cases, municipal GHG emissions constitute a small proportion of the total emissions in a city.

Seeking to govern climate change through the **provision** of infrastructure and services has the potential for far-reaching impacts on urban GHG emissions. Efforts may include reducing the carbon intensity of energy, water and waste services, reducing the carbon footprint of the built environment, fostering sustainable forms of urban development and providing low-carbon energy and travel choices for households and businesses. This potential appears to be most significant in cities where municipal governments may retain ownership or control of infrastructure networks and where basic needs have been met – therefore normally in developed countries.

Although the **regulation** mode of governing is the least popular approach adopted by municipal governments, it can be very effective in terms of reducing GHG emissions. Three different sets of mechanisms are deployed in this mode. First, and least common, local governments may use taxation and charge user fees. Second, the use of land-use planning is an area where municipal competencies are often strong (at least in developed countries) and their powers can be used to stipulate urban densities and to promote mixed land use. The setting of codes, standards and regulations is a third approach. This is most common in the built environment sector, where they are often set by national governments, although examples can also be found at the municipal level.

However, regulation can be difficult to implement. Municipalities may also lack the institutional capacity to enforce regulations, particularly in cities in developing countries with limited resources.

In the **enabling mode**, municipalities deploy mechanisms to support the reduction of GHG emissions by other local actors. There are three main approaches for this: First, various forms of information and education campaigns have been implemented to effect behavioural change. Second, municipal governments can use incentives of various kinds – including grants, loans and the removal of subsidies or barriers to the adoption of new technologies – to encourage the uptake of low-carbon technologies or to promote behavioural change. Third, various partnerships with business and civil society organizations to reduce GHG emissions have been developed.

There are two critical limitations to the enabling approach of governance. First, such initiatives are restricted to those who are willing to participate. Second, the voluntary nature of such initiatives means that they are difficult to monitor and verify, and cannot be 'enforced', but rather depend on the capacity of municipal governments to persuade others to take action.

Public–private collaboration in urban climate governance

The growing importance of corporate, donor and civil society actors means that (quasi) private modes of governing – such as voluntary, private provision and mobilizing – are also becoming important. This level of collaboration and engagement by non-government actors can be found in both developed and developing countries, and across the urban development, built environment, urban infrastructure, transport and carbon sequestration policy sectors.

Three approaches appear to be gaining ground here, which in some ways mirror those being deployed by municipal authorities:

- **voluntary** – the use of 'soft' forms of regulation to promote action either within an organization or amongst a group of public and private actors, combining features of the self-governing and regulation modes detailed above;
- **public–private provision** of low-carbon infrastructures and services, either in place of or in parallel to government schemes, including initiatives developed through the auspices of the Clean Development Mechanism (CDM); and
- **mobilization**, where private actors seek to engage other organizations in taking action, such as through education campaigns.

However, partnerships should not be treated as a *panacea*. Coordinated action requires both substantial commitments from the partners and the ability of the organizations to participate effectively. Partnerships can also be exclusive, serving to promote the interests of one group of actors at the expense of others.

OPPORTUNITIES AND CONSTRAINTS

Significant efforts are taking place to mitigate climate change in urban areas across the world. Yet, in most cities mitigating climate change remains a marginal issue, and despite ambitious policy targets, the realities of reducing GHG emissions are often more challenging than anticipated. The overall picture is one of policy fragmentation. Islands of best practice can be identified but comprehensive approaches to addressing climate change remain the exception rather than the rule.

The critical factor shaping urban responses to the challenges of mitigating climate change seems to be governance capacity. In this context, the opportunities and constraints that shape governance capacity can be considered in three broad categories: factors that are institutional, those which are technical or economic, and those which are political in character (see Table 5).

Institutional factors shaping urban governance capacity

Institutional factors which shape urban governance capacity include: issues of multilevel governance (municipal competencies and the relationships between different institutions at international, national, regional and local levels); policy implementation and enforcement; and the presence of alternative institutional arrangements, such as international networks and partnerships, through which governance capacity can be generated.

Urban responses to climate change do not take place within a policy or political vacuum. While municipalities are more or less coherent and have varying degrees of autonomy from international policies and from regional and national governments, the relationship between these arenas of authority is critical in shaping the capacity to govern climate change. This is the 'multilevel' governance of climate change.

At the city-region scale, a key issue concerns the fragmentation of urban governance across multiple authorities. This challenge of horizontal coordination has been exacerbated in many countries in the wake of neo-liberal reforms, which have led to the privatization or contracting out of what were previously municipal services, and therefore increasing the number of actors with which policy coordination needs to be undertaken.

An additional set of institutional factors that shapes urban climate change governance capacity is the ability to implement and enforce policies and measures. In many policy

	Examples of opportunities	Examples of constraints
Institutional	• Proactive national/regional government • Membership of international municipal networks • Formation of partnerships	• Limited formal powers for municipal authority • Absence of policy coordination
Technical and economic	• Knowledge of urban GHG emissions • Availability of external funding • Flexible internal finance mechanisms	• Lack of expertise • Lack of financial resources • Suitability of technology
Political	• Political champions • Recognition of co-benefits • Political will	• Departure of key personnel • Prioritization of other policy agendas • Conflicts with other critical economic and social issues or sectors

Table 5

Opportunities and constraints for governing climate change mitigation in the city

areas, municipal authorities, particularly but not exclusively those in developing countries, are unable or unwilling to enforce regulations and standards. The effectiveness of energy standards may therefore be particularly low in developing countries, given difficulties with enforcement and corruption.

Equally, the challenges of implementation are not confined to municipal authorities. Given the voluntary nature of many of the schemes being developed by the private, civil society and donor communities in cities to address climate change, issues of compliance, monitoring and verification of achievements also affect urban governance capacity.

Technical, material and financial factors shaping urban governance capacity

Issues concerning technical expertise (and skills shortages), the material infrastructures and cultural practices that determine the possibilities for action (as well as the financial resources available) will affect how urban authorities can respond to climate change mitigation imperatives.

There are two main ways in which the availability of scientific expertise and knowledge has shaped urban governance capacity for mitigating climate change. First, the growing scientific consensus internationally about the nature of the climate change problem and the need for urgent action has been a motivating factor for many municipalities. Second, scientific knowledge has also been significant in the development of local inventories and forecasts of GHG emissions.

The opportunities and constraints facing the urban governance of climate change are also structured by the social and technical networks that constitute cities – the 'seamless web' of material infrastructures and everyday practices that sustain them.

Furthermore, financial resources are both a driver and a barrier for fostering urban responses to climate change. Municipal authorities lacking the finances to provide even basic services for their constituents are unlikely to invest in climate change mitigation, given the many competing issues on urban agendas. While this is an acute challenge for cities in developing countries, a lack of adequate finance can also act as a barrier to action on climate change mitigation in cities in developed countries.

Access to external sources of funding is also a key factor shaping local capacity to address climate change. Such sources of funding may come from the European Union, national governments, through partnership arrangements, or donor organizations. International municipal networks, such as ICLEI's Cities for Climate Protection campaign and the C40, have been critical in leveraging funding for municipalities.

Political factors shaping urban governance capacity

Political factors that shape the opportunities and constraints for urban climate governance can be considered in terms of issues of leadership (individual and organizational), questions of opportunity (windows of opportunity), the framing of the costs and benefits of acting on climate change, and underlying structures and processes of political economy.

Several studies have demonstrated that individual political champions or policy entrepreneurs have been critical to the development and pursuit of policies and projects at the urban level. At the organizational level, leadership is also an important factor shaping urban governance capacity. Opportunities to be at the forefront of initiatives amongst a peer group have, for instance, provided the impetus for action in the urban arena.

The presence of committed individuals and an institutional framework within which acting on climate change is supported also provides a basis upon which windows of opportunity can be used to further climate change policy ambitions. Such opportunities can take the form of specific climate change initiatives, trigger events that create the political and physical space for interventions in the city, or sources of funding or political support that can be diverted for climate change ends.

At the same time, struggles have emerged over whether cities should or should not be addressing climate change. In many cities, the arguments 'not on my turf' and 'not in my term' are prevalent, particularly in developing countries where resources are limited, other concerns may take prominence. In more affluent urban contexts, efforts to mitigate climate change are often in direct conflict with dominant urban political economies and may encounter significant opposition, while in developing countries where resources are particularly limited other concerns may be more pressing.

The bundling of climate change mitigation with other potential social or environmental benefits (synergies and co-benefits) at the city level may be a potential trigger of climate change action and a factor that may determine the long-term success of the initiatives. Such strategies may be particularly important in contexts of ambiguous or overtly hostile responses to addressing climate change in cities.

COMPARATIVE ANALYSIS

From a handful of pioneering cities in the 1990s, the number of urban municipalities participating in climate change mitigation efforts has expanded significantly over the past two decades. This reflects the changing international and national climate change policy context in which developing countries with growing contributions to global emissions – including China, India, Brazil, Mexico and South Africa – are becoming involved in mitigation efforts.

Data on the strategies and measures being adopted in cities across the world is limited, especially for cities in developing countries. In addition, evidence concerning the impacts and effectiveness of climate change mitigation measures is scarce, making a detailed comparative analysis of urban climate change mitigation efforts impossible. Nevertheless some key trends can be observed.

- First, climate change remains a marginal issue for most of the world's cities. In addition there are few examples of inclusive and participatory approaches to urban climate change mitigation governance. Governing climate change mitigation is primarily being undertaken by municipal governments, although forms of partnerships and the involvement of private actors is increasingly important.
- A second set of trends concern regional differences in terms of what cities are doing and how they are doing it. In developed countries, emphasis has been placed on the energy sector through urban design and development, the built environment and urban infrastructure systems. In developing countries, cities have focused on a more diverse range of urban infrastructure projects, including waste and water systems, as well as issues of carbon sequestration. However, this broad brush differentiation between developed and developing countries obscures the differences that are emerging within these regions.
- A third set of trends relates to the differences in the opportunities and constraints that municipal governments and other actors face in seeking to mitigate climate change. For many cities in developed countries a lack of resources is seen as a critical barrier to action, though these challenges are considerably higher for cities in developing countries.

As a result, rather than being regionally differentiated, future urban climate change mitigation efforts may be characterized by differences between an elite group of cities with access to substantial resources, primarily in developed countries, and the vast majority of cities for whom addressing climate change will remain a low priority.

CHAPTER 6

CLIMATE CHANGE ADAPTATION RESPONSES IN URBAN AREAS

The lives and livelihoods of hundreds of millions of people will be affected by what is done (or not done) in urban centres with regard to adapting to climate change over the next decade. Action is urgently needed, both to address current risks and to begin building into urban fabrics and systems resilience to likely future risks. It is generally much easier to make provisions now for likely future climate-related risks – in infrastructure expansion, new buildings and new urban development – than to have to retrofit buildings, redo infrastructure and readjust settlement layouts in the future.

Therefore, what most urban centres in developing countries need is not a climate change adaptation programme but a development programme – into which measures for climate-change adaptation are integrated.

HOUSEHOLD AND COMMUNITY RESPONSES TO THE IMPACTS OF CLIMATE CHANGE

Individuals and households take measures to reduce risks from extreme weather events such as flooding or extreme temperatures. Most of these responses are impact-reducing, *ad hoc*, individual short-term efforts to save lives or to protect property.

Wealth helps individuals or households buy their way out of risks – for instance by being able to purchase, build or rent homes that can withstand extreme weather in locations that are less at risk from flooding. Higher-income groups can also afford the measures that help them cope with illness or

Box 6 Understanding adaptation

Adaptation to climate change refers to actions to reduce the vulnerability of a system (e.g. a city), population group (e.g. a vulnerable population in a city) or an individual or household to the adverse impacts of anticipated climate change.

Adaptation deficit is the lack of adaptive capacity to deal with problems caused by climate variability and climate change and is strongly related to the deficit in infrastructure and service provision and in the institutional and governance system that is meant to be in place to ensure adaptation.

Adaptive capacity is the inherent capacity of a system (e.g. a city government), population (e.g. a low-income community in a city) or individual/household to undertake actions that can help avoid loss and can speed recovery from any impact of climate change.

Maladaptation refers to actions and investments that increase rather than reduce risk and vulnerability to the impacts of climate change.

Residual damage refers to damage caused by climate change that is permanently beyond adaptation.

Resilience is the outcome of successful adaptation – and is a product of governments, enterprises, civil society organizations, households and individuals with strong adaptive capacity.

Vulnerability is the opposite of adaptive capacity.

Cities will need to invest in infrastructure for climate change adaptation

injury when they are affected or when their assets are damaged.

Community-based adaptation is a process that recognizes the importance of local adaptive capacity and the involvement of local residents and their community organizations in facilitating adaptation to climate change. Where there are representative community-based organizations, the possibilities of building resilience to climate change are much greater. In many countries, there are now national federations of slum and shack dwellers that have community-based savings groups as their foundation. Small-scale loans managed by these savings groups and repaid over short time periods provide much-needed capital for livelihood activities, or responses to shocks and stresses.

Much adaptation (and disaster risk reduction) needs the installation and maintenance (and funding) of infrastructure and services that are at a scale and cost that are beyond the capacity of individuals or communities. Yet, in many countries, especially where local governments are weak or ineffective or significant populations live in informal settlements, households and community responses are often the only adaptation responses that are actually implemented.

Effective risk reduction is possible if household, community and government investments and actions work together in coordinated manner, but generally middle- and high-income groups face much lower levels of risk, and usually have much less need for community-based action to remedy deficiencies in infrastructure and services.

LOCAL GOVERNMENT RESPONSES TO THE IMPACTS OF CLIMATE CHANGE

The main responsibility for implementing policies to address the impacts of climate change in cities rests with local governments. Yet, many city governments around the world have so far failed to accept and/or act on this responsibility, with the result that many households and communities have been forced to implement climate change adaptation measures on their own.

Furthermore, many governments in developing countries are initiating national studies of the likely impacts of climate change and developing 'National Adaptation Programmes of Action'. But, many give surprisingly little attention to urban areas, considering the importance of urban economies to national economic success and for most countries, to the incomes and livelihoods of much of the popul-

Cities will have to adapt coastal residential and commercial buildings to climate change impacts

ation. Thus, it has been suggested that what is needed is city-focused 'City Adaptation Programmes of Action' and local-focused 'Local Adaptation Programmes for Action'.

Local government responses in developing countries

Generally, the first evidence of an interest by city or municipal government in climate change is an interest in assessing the scale and nature of likely risks. However, such assessments are not easily done for most developing country cities because of the lack of basic data on environmental hazards and risks (or even of an accurate and detailed map with all settlements on it).

Some developing country cities have started the process of reacting to vulnerability by assessing the risks likely to be caused by future climate change. Clearly, there is still a need to incorporate measures to address these risks into city plans, land-use management, infrastructure investments, service provision, building and planning codes. There is little evidence of this taking place.

Moving from risk assessment to adaptation strategies, however, has not been easy. Within Africa, South Africa is unusual in having discussions within several city governments on climate change adaptation and, thus, moving beyond risk assessments to discuss what should be done to address the risks. A number of South African cities have thus developed plans for adapting to climate change.

In addition, it is important to note that most climate change-related risks in developing country cities are an exacerbation of risks already present, which are the result of the inadequacies in local governments' capacities or willingness to manage and govern urban areas.

Local government responses in developed countries

A number of cities in developed countries, such as London, Melbourne and Rotterdam, have taken the first step to assess new or increased risks expected to emerge with climate change and the related impacts. They have also gone further to identify adaptation options, including all the sector-specific actions required for this.

Adaptation responses in cities in developed countries are generally much easier to formulate, implement and fund, although not necessarily easier in terms of getting the needed political support. Such cities do not have very large deficits in infrastructure. These cities also, normally, have a range of

regulations and controls that (when implemented) reduce risks, as well as measures and institutional arrangements that ensure rapid and effective response to disasters.

While the scale of risks and the populations exposed to them are much smaller and local capacities to address these much larger, this does not mean that adaptation is necessarily given the priority it deserves. Many relatively wealthy cities need major upgrades in their infrastructure that should take account of likely climate change impacts. Further, most cities in developed countries need to expand their capacity to anticipate and manage extreme weather events. There are also cities that are on sites that are or were relatively safe without climate change but that now face new levels of risk. For instance, many coastal settlements face increased risks from sea-level rise.

The links between adaptation and disaster preparedness

The 1990s brought a shift in the way that disasters and their causes are understood, with much more attention being paid to the links between development and disasters. In Latin America, many city governments began to explore this and implement disaster risk reduction measures. This was spurred by the numerous major disasters in the region and supported by decentralization processes and state reforms in many countries. Several countries enacted new legislation that transformed emergency response agencies into national risk reduction systems. Some city governments incorporated disaster risk reduction into development as they changed or adjusted regulatory frameworks, upgraded infrastructure and housing in at-risk informal settlements and improved urban land-use management with associated zoning and building codes.

These events encouraged countries, and within these, city and municipal governments, to look more closely at the scale and nature of disaster risk and consider what investments and measures could be put in place to reduce such risks. These have relevance for climate change adaptation because many are reducing risk levels or exposure to risk for the extreme weather events that climate change is making (or is likely to make) more intense, frequent or unpredictable. Yet, climate change poses a new set of risks that may be substantially different from those experienced in the past, and the challenge for adaptation is to ensure that both development needs, and the needs imposed by a changing climate (and their link to disaster risk) are met simultaneously.

TOWARDS EFFECTIVE CITY-BASED CLIMATE CHANGE ADAPTATION STRATEGIES

There is evidence of the beginnings of city-based adaptation strategies in certain cities. These are what might be called the early adapters as well as the early adopters. As yet, too few cities have developed coherent adaptation strategies and even fewer have strategies that have begun to have a real influence on public investments or effect needed changes in building and infrastructure standards and land-use management.

It is possible to identify key components for developing and enhancing city adaptation strategies. These would include: the need to build commitment among different stakeholders, develop or expand the information base on current conditions, initiate risk/vulnerability assessments, assess sector-specific vulnerability and responses, develop strategic plans for the city as a whole and its surrounds, and support local responses to climate change.

Furthermore, climate change adaptation action is needed in almost all sectors relating to local urban government; Table 6, drawn from the IPCC, provides some examples of the kinds of specific adaptation interventions needed by some of the key sectors. Much of what is listed in the adaptation option/strategy (in this table) will fall to local government to implement, even if it needs resources and policy and regulation frameworks from higher levels of government.

The **building of resilience** can be understood as a way of enabling not only coping with added shocks and stresses, but also addressing the myriad challenges that constrain lives and livelihoods. Thus, a key part of building resilience is facilitating poverty reduction and more general improvements to the quality of human lives. Many interventions being undertaken in urban areas around the world – by local, municipal, national and international stakeholders – contribute to building this resilience through improving housing, infrastructure and services, particularly for the urban poor. Indeed, for many cities in developing countries, poverty alleviation and other pro-poor policies at the urban level are likely to be the single most important component of an overall adaptation strategy.

Many urban areas in developing countries already experience an 'adaptation deficit' whereby existing infrastructure is insufficient to cope with present climatic conditions – let alone those that will arise as a result of climate change. The adaptation needs for these urban areas are thus based on the need for development that takes a

Sector	Adaptation option/strategy	Underlying policy framework	Key constraints to implementation	Key opportunities to implementation
Water	Expanded rainwater harvesting; water storage and conservation techniques; water reuse; desalination; water-use and irrigation efficiency.	National water policies and integrated water resources management; water-related hazards management.	Financial, human resources; physical barriers.	Integrated water resources management; synergies with other sectors.
Infrastructure and settlements	Relocation; sea walls and storm surge barriers; dune reinforcement; land acquisition and creation of marshlands/wetlands as buffer against sea-level rise and flooding; protection of existing natural barriers.	Standards and regulations that integrate climate change considerations within design; land-use policies; building codes; insurance.	Financial and technological barriers; availability of relocation space.	Integrated policies and management; synergies with sustainable development goals.
Human health	Heat–health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation.	Public health policies that recognize climate risk; strengthened health services; regional and international cooperation.	Limits to human tolerance (vulnerable groups); knowledge limitations; financial capacity.	Upgraded health services; improved quality of life.
Tourism	Diversification of tourism attractions and revenues; shifting ski slopes to higher altitudes and glaciers; artificial snow-making.	Integrated planning (e.g. carrying capacity; linkages with other sectors); financial incentives (e.g. subsidies and tax credits).	Appeal/marketing of new attractions; financial and logistical challenges; potential adverse impact upon other sectors (e.g. artificial snow-making may increase energy use).	Revenues from 'new' attractions; involvement of wider group of stakeholders.
Transport	Realignment/relocation; design standards and planning for roads, rail and other infrastructure to cope with warming and drainage.	Integrating climate change considerations within national transport policy; investment in research and development for special situations (e.g. permafrost areas).	Financial and technological barriers; availability of less vulnerable routes.	Improved technologies and integration with key sectors (e.g. energy).
Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources; reduced dependence on single sources of energy; increased efficiency.	National energy policies, regulations, and fiscal and financial incentives to encourage use of alternative sources; incorporating climate change in design standards.	Access to viable alternatives; financial and technological barriers; acceptance of new technologies.	Stimulation of new technologies; use of local resources.

Source: Based on Parry et al, 2007, Table SPM4

Table 6

Examples of specific adaptation interventions by sector

changing climate into account and a reckoning that the future will be more hostile for many urban residents.

Many communities are also already involved in activities that will build the resilience of individuals and households, including through savings schemes. While insurance policies contribute to resilience, they remain unaffordable for most of the population and most enterprises in developing country cities.

Adaptation planning and local governance

Urban adaptation planning is intrinsically linked with local governance. This includes decentralization and autonomy, accountability and transparency, responsiveness and flexibility, participation and inclusion, and experience and support. Urban governance systems that exhibit these characteristics are better able to build resilience through

Urban vulnerability to climate change will depend on levels of disaster preparedness

having more effective financial and technical management capacities in 'climate-sensitive' sectors such as waste, water and disaster management. Responsiveness and flexibility are also crucial, given the limited predictability of the consequences of climate change. At the same time, the involvement of the poor and marginalized groups in decision-making, monitoring and evaluation is key to improving the living conditions of these groups.

In urban areas of developed countries, citizens take for granted that a range of local government structures and organizations provide protection from environmental hazards, help create resilience to potential disasters and provide for adaptation to climate change. In urban areas in developing countries, these facilities and services are frequently absent or they serve only a proportion of the population. Local governments, lacking capacity and funding and with large infrastructure and service deficits, can benefit significantly from the contributions that community-based organizations can bring.

Some urban areas have developed plans for adaptation at both the city and sectoral levels as a key component of their preparation for climate change. These provide the framework within which local government departments, the private sector, civil society, and individuals can prepare and implement their contributions to strategies for adaptation within development or investment plans. Participatory budgeting has become one of the best known and most widely applied forms of citizen engagement in the plans and priorities of city governments, and in some cities, this engagement has included a strong focus on environmental issues.

The need to adapt to climate change and the need to adapt governance systems to be more responsive and effective are thus closely linked. This includes decentralization and autonomy, accountability and transparency, responsiveness and flexibility, participation and inclusion, and experience and support.

FINANCING ADAPTATION

Funding for adaptation in developing countries comes (and will come) primarily from two main sources: the dedicated climate change funds available under the UNFCCC and through overseas development assistance. However, in practice, the funds available are at present inadequate and do not target urban settlements. So far, urban priorities also seem to be absent from the funding allocated through the Adaptation Fund.

The Copenhagen Accord and the Cancún Agreements include commitments to expand considerably the scale of funding available for adaptation, although the wording on where the increased funding will actually come from is ambiguous. There is also a concern that developed countries may choose to prioritize any funding that they provide for mitigation because it is more in their interest than adaptation.

The Adaptation Fund was established to finance adaptation projects and programmes in developing countries, with particular attention to those countries that are particularly at risk from the adverse effects of climate change. It is likely to have particular importance because part of its funding comes from a levy on the project activities of the 'Clean Development Mechanism' and this should give it a considerable and guaranteed source of funding. Thus, unlike the other funds, it is not reliant on negotiating funding from donor agencies.

There is an opportunity for complementarities between the Adaptation Fund and overseas development assistance. This mix of funding might also overcome the contentious issue of the boundary between climate change

adaptation and development. Development should clearly include 'adaptation' to all disaster and environmental health risks, including those to which climate change does not contribute or only partially contributes. As discussed earlier, the large climate change adaptation deficit in most developing countries is also a development deficit.

Attention should also be paid to the relative costs of mitigation and adaptation. The estimates for the costs of mitigation (achieving the needed reductions in global GHG emissions) appear very high. Many estimates for the costs of adaptation – including those produced by the UNFCCC – are much lower.

The costs of adaptation

The basis for accurate national and global estimates of the costs of adaptation does not exist and therefore discussions on this issue are problematic. Most global estimates are based on the costs of climate-related disasters but these are known to form a very inadequate basis for a full and accurate costing. Many estimates for the costs of adaptation that are relevant to urban areas are based on the costs of adapting infrastructure and, thus, include roads and bridges, railways, airports, ports, electric power systems, telecommunications, water, sewerage and drainage/waste water management systems as well as social infra-structure such as public transport, healthcare, education and emergency services.

The destruction of, or damage to, housing is one of the most common and most serious impacts of many extreme weather events, especially in many developing countries. However, assessing the impacts of such events in terms of the value of property damaged or destroyed can be misleading; an event that is devastating to the lives of very large numbers of people (in deaths, injuries and loss of property) may have low economic impacts because of the low value assigned to the housing damaged or destroyed.

The infrastructure deficit

Developing countries have very large deficiencies in terms of their provision of infrastructure. During the period from 2000 to 2010, the number of slum dwellers in developing countries has increased from 767 million to 828 million. A large proportion of the slums are characterized by inadequate or no provision of basic infrastructure (i.e. no all-weather roads, no drains, no piped water supplies and no provision for electricity or sewers). These deficiencies represent a very large climate change adaptation deficit, much of which is an infrastructure and institutional deficit.

The premise for UNFCCC's estimates of the costs of adapting infrastructure – that this can be costed by applying a small increment to existing investment flows into infrastructure that is climate sensitive – has been critiqued as it does not take account of the very large infrastructure deficits. It also leads to the conclusion that most of the investment needed for climate change adaptation for infrastructure is required in developed countries, rather than in developing countries.

Adaptation will require very large capital sums invested in developing countries to reduce the deficit in infrastructure needed for disaster risk avoidance and risk reduction. However, at present, there are no reliable methodologies for estimating these costs accurately. There is a need for detailed case studies of what adaptation would involve in particular locations and what component would have to be allocated to infrastructure deficits.

However, it would only take a few such studies of major cities that are particularly at risk from climate change and have large infrastructure deficits to show that the UNFCCC estimates for Africa and for most cities in Asia are far too low. It is also likely that studies of major cities in Latin America at high risk from climate change would show the UNFCCC estimates for these regions are underestimated.

CHALLENGES TO ADAPTATION

The majority of the urban centres most at risk from climate change are in developing countries, and it is in urban areas in developing countries that the deficits in infrastructure and services needed to protect populations from climate change are most evident. Despite this, most governments and many international agencies still give little or no attention to urban adaptation.

The most pressing challenge is to have adaptation priorities recognized as a central dimension of development – and, thus, also a central dimension of economic strength and poverty reduction. If the Millennium Development Goals were met in urban areas, it would increase their resilience to climate change for millions of citizens – in particular low-income households. However, the threats and challenges to fully embracing adaptation at the urban level are many. Some of these include:

- With investment capacity so constrained in most urban centres in developing countries, the extra costs of building resilience to future risks will be contested by

those who claim that there are more pressing priorities.
- Effective action on adaptation on the ground depends on a willingness to act by local governments, which is often not evident.
- For (local and national) governments in countries with minimal per capita GHG emissions, it is very difficult to justify to their electorates expenditures on climate change mitigation if they are already unable to provide their populations with basic infrastructure and services.
- In each country and urban centre, different stakeholders may be working according to very different worldviews of adaptation. This may hamper efforts at creating coherent and holistic adaptation responses.
- Little attention is given to urban adaptation by most international agencies, even as they discuss and develop policies on adaptation.
- Getting international support available in a form that allows it to support effective urban adaptation which is integrated into local development (and build local adaptation capacity) is problematic.
- There is little clarity as yet on how international funding for adaptation (particularly integrated into development) can work with and serve local governments and civil society groups within each urban centre.
- The ongoing failure to mitigate sufficiently in developed countries will create ever more adaptation failures, mostly in developing countries (including many countries with insignificant historic and current contributions to climate change).
- If cities become the destination of flows of rural migrants driven from their homes and livelihoods by the damages brought by climate change to agriculture, for example, it will add further to the infrastructure deficit and probably to the scale of settlement on hazardous sites.
- Yet, a failure by governments and international agencies to reduce global GHG emissions and to support rural and urban populations to adapt will bring crisis-driven population movements that make those forced to move very vulnerable.
- In the case of 'climate migrants' there is no clarity on which international body would assist such groups. There are calls for the development of new international legislation to address the concerns of 'climate migrants' – perhaps in the form of an international convention for persons displaced by climate change.

CHAPTER 7

CONCLUSION AND POLICY DIRECTIONS

This chapter briefly revisits the constraints and opportunities of mitigation and adaptation, and highlights and the multiple linkages, synergies and trade-offs between mitigation, adaptation and urban development. The chapter then presents future policy directions, focusing on local, national and international principles and policies for supporting and enhancing urban responses to climate change.

ADDRESSING URBAN GHG EMISSIONS AND VULNERABILITIES: CHALLENGES, CONSTRAINTS AND OPPORTUNITIES

This section explores the challenges, constraints and opportunities of efforts to decrease urban GHG emissions and thereby enhance society's resilience to climate change. The global mitigation challenge will be to achieve development paths that will bring down emissions by 2015 and stabilize them by the end of the century at 445–490 parts per million CO_2eq by volume. Only in this way can the global average temperature increase be kept below 2°C which, as recognized in the Copenhagen Accord, is necessary to prevent harmful human interference with the climate system.

Considering an estimated global population of 9 billion by 2050, and an increasing urban share of that population, this means individual carbon footprints around the world will have to be kept at an average of less than 2.2 tonnes per year. At present, annual per capita emissions in some US cities reach (or even exceed) 20 tonnes of CO_2eq. Thus, there is a need to reduce the emissions of many cities and citizens in developed countries (and even in some developing countries) considerably. In order to address this challenge, multilevel and multi-sectoral actions – including many measures at the urban level – will need to achieve:

- reductions in the quantities of fossil fuels used;
- reductions in the carbon content of the fossil fuels used (such as a switch from coal to natural gas); and
- changes in the energy structure (such as increased reliance on renewable energy sources) by switching to other sources of energy, while maintaining the quality of energy provision.

Globally, urban local authorities have a highly variable level of influence over GHG emissions, but cities are and can contribute to addressing the mitigation challenges of climate change in several ways:

- as initial seedbeds and niches for entrepreneurial experiments with radically new technologies (by commercial private-sector actors);
- as lively laboratories for experimentation among emerging and future-looking communities that share particular perceptions, visions and ideas as to how to move urban communities away from current unsustainable development paths; or
- as communities that build networks and platforms (such as workshops, conferences) to facilitate the exchange of knowledge and experiences, as well as the articulation of best practices.

The greatest responsibility for fighting climate change lies with developed countries

Involved stakeholders do acknowledge the urgency of mitigation, and action is taking place at different levels of govern-ment, but not at all levels, nor with the required effectiveness. And, although climate change is firmly on the urban policy agendas in both developed and developing countries, it remains a marginal issue in terms of implementation.

Diverse institutional factors explain the challenges, constraints and opportunities of mitigation responses by local authorities including: international and national policies which provide the enabling – but also constraining – context within which urban responses are framed; local authorities' institutional ability to implement and enforce policies and regulations; the availability of financial resources and technical expertise; and the weight of such structural and enduring factors as the material infrastructure and cultural practices of a city.

As for financial resources, given the many competing demands in urban areas, local authorities lacking the money to provide even basic services for their constituents are unlikely to invest in climate change mitigation. Furthermore, the international financial resources available for mitigation (and adaptation) activities under the UNFCCC and the Kyoto Protocol are quite simply not sufficient to meet the requirements, particularly of developing countries. In addition, very limited resources have so far been made available for initiatives in urban areas.

Regardless of the scale of mitigation undertaken over the next two to three decades, adaptation action will be necessary, which will be another challenging and fundamental dimension of the urgent response to climate change. Even if effective actions are taken now to stabilize emissions around the end of the century, GHG emissions are likely to continue to increase until 2030. Thus, adverse impacts of projected climate change and variability are inevitable, and urban centres will be particularly at risk.

The responsibilities of local authorities with regard to the built environment, infrastructure and services that have relevance for adaptation include:

- urban planning and regulatory instruments designed to influence land availability and to authorize and oversee hazardous activities that can produce disasters;
- provision and pricing of various public services, infrastructure and resources; and
- enabling, proactively facilitating and coordinating actions to manage hazards through partnerships with the private sector, the academic sector, non-governmental and

grassroots actors (e.g. households and communities) to reduce risk.

As with mitigation, adaptation is already taking place, at least on a small scale, and the world is witnessing the beginnings of city-based adaptation strategies in certain urban centres. As yet, however, too few cities have developed coherent adaptation strategies. The relatively lower emphasis on adaptation, and particularly on urban adaptation, is partly a result of the existing structure of incentives under the UNFCCC.

A fundamental challenge in this context relates not only to whether adaptation is effectively responding to potential climate change impacts in different sectors, but also to social equity issues, i.e. whose needs are served (and whose are not) by adaptation responses, especially in relation to income, gender and age.

In urban areas of many developing countries, household, community and government adaptation responses will need to happen in the context of adaptation (or development) deficits. As detailed previously, it is impossible to adapt or climate-proof infrastructure, services and emergency responses that do not exist.

ADAPTATION AND MITIGATION: RELATIONSHIPS WITH URBAN DEVELOPMENT AND POLICY

Early experience with both adaptation and mitigation planning in developed country cities suggests that attention should be given to the synergies and trade-offs between actions addressing climate change mitigation and adaptation, as well as other dimensions of policy-making. However, experiences from many cities in developing countries contradict this, as their leaders and stakeholders tend to consider developed countries the culprit of climate change and, thus, responsible for mitigation practices. Such cities tend to focus on adaptation interventions as independent initiatives.

Climate change mitigation and urban development

Recent analyses of potential GHG emission reduction and efficiency improvement indicate that the world seems headed toward climate changes that are even more severe than the sobering descriptions outlined earlier in this report. Two apparent crises lie ahead: First, a crisis of emerging impacts in vulnerable cities as they become ever more urgent. Second, a crisis of global responses to growing pressures for mitigation and adaptation, which are likely to be sources of great controversy and perhaps forceful policy developments.

Globally, the mitigation challenge is to reduce GHG emissions from buildings, industry, transportation, energy production and land use, and to reduce or reverse deforestation. It is important to note that mitigation policies can represent opportunities for cities and their development prospects in terms of saving money, creating jobs and generating new streams of tax revenues.

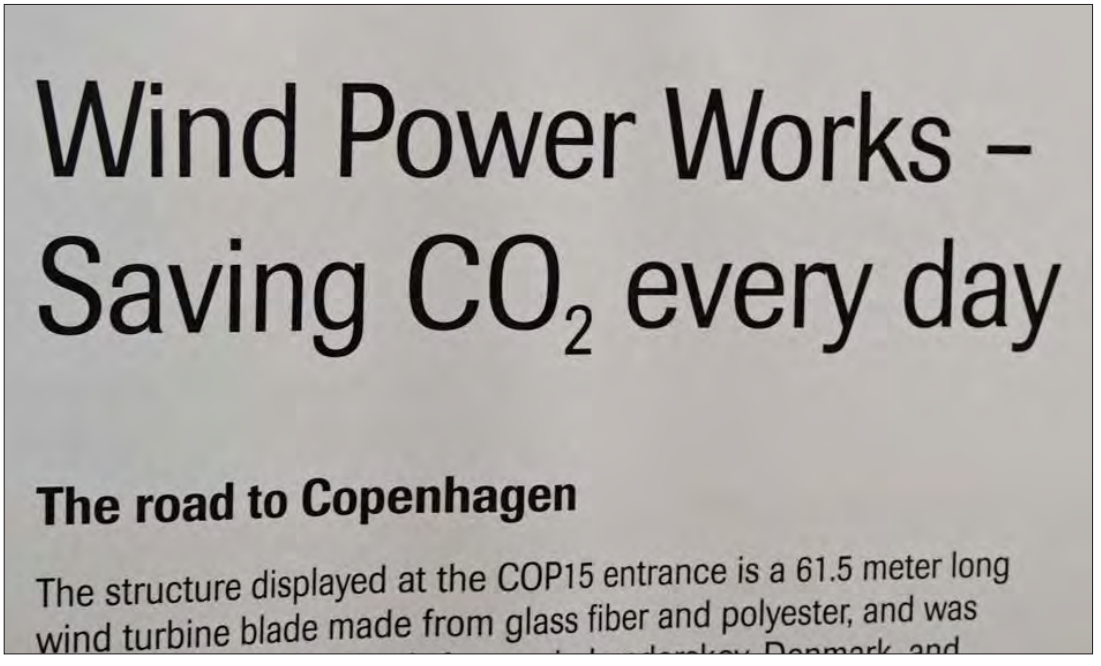
But global pressures to push the boundaries of climate change mitigation are likely to be a challenge for urban development as well. Two potential impacts are especially important. First, if an urban area's economy depends, even in part, on fossil energy production, it is likely to be adversely affected by any move away from fossil energy. A second impact is that energy costs and prices are likely to increase in most parts of the world as energy systems shift from relatively low-cost fossil energy sources to somewhat more expensive alternative energy systems. Yet, affordable energy is an essential driver of the development engines of many cities. In most cases in developing regions, paths for socio-economic and technological development imply increases in GHG emissions, not reductions in emissions, including both emissions from the cities themselves and emissions from systems that meet urban needs, such as electric power plants located elsewhere.

It thus becomes necessary to take advantage of existing synergies between climate protection and other development priorities. For instance, strong synergies exist in the transportation sector between climate change and energy supply and security. However, attention needs to be given not only to the synergies, but also to the conflicts between these policy domains. For instance, increases in the energy efficiency of vehicles can result in increased atmospheric emissions and, thus, in negative health impacts, if vehicle travel distances increase or drivers switch to vehicles with larger engines (the 'rebound effect').

Climate change adaptation and urban development

Climate change impacts are a critically important challenge for urban development, and if climate change is severe (rather than moderate), the number of cities at risk will be multiplied many times over.

One of the most fundamental challenges in relating



Renewable energy offers promising potential for urban GHG mitigation

climate change adaptation with urban development in many regions, however, is a limited capacity to identify vulnerabilities and adaptation pathways, along with a limited capacity to make adaptation happen. Many small- and medium-size cities, especially in sub-Saharan Africa, South Asia and Central America, currently show low levels of capacity to adapt to the current range of climate variability, let alone any future climate change impacts. Problems in many such cities include a lack of provision for infrastructure (including all-weather roads, piped water supplies, sewers, drains, electricity, etc.), urban social services (such as health and education) and a lack of institutional capacity.

Yet, other cities have shown an ability to adapt to local climate conditions, whether related to climate change or not; and, where climate change adaptation is being considered seriously. In nearly every case adaptation options are being identified that are relatively low cost, have broad constituency support and offer considerable co-benefits.

Mitigation and adaptation: Seeking synergies rather than conflicts

It is now known that neither mitigation nor adaptation alone can protect the world from the undesirable impacts of climate change. Both must be a part of the global response. Mitigation is essential in order to keep climate change impacts as low as possible, but some impacts can no longer be avoided. This is so because progress is slow on international agreements to implement mitigation, and strategies for GHG emission stabilization in major developing countries are unclear at best. Adaptation is, therefore, essential because some impacts will not be avoided.

Cities are one of the most important of all the world's settings for integrating actions to reduce vulnerabilities and mitigation responses as they relate to broader social and economic objectives, such as job creation, improvements in the quality of life, and access to health and water services. The fact that climate change response planning often catalyses these discussions within communities is one of its most important co-benefits.

A major problem is that mitigation and adaptation options often differ in important ways. Furthermore, it is also important to note that mitigation actions are urgent. If no action is taken in the next ten years or so, the impacts will exponentially increase. This is less the case with adaptation action, which can be phased in time and which will be a continuous process for many decades to come.

Currently, and with some notable exceptions, most

urban initiatives that might be associated with mitigation or adaptation are fragmented, and historically much of the policy attention has been focused mainly on mitigation, with little or no consideration of adaptation. In many cases, the focus is not on climate concerns but on energy security and other development priorities related to economic growth.

Only a handful of city-wide initiatives – such as in London (UK), Durban (South Africa) and New York (US) – are beginning to grasp the need to address at least some of the complex linkages between mitigation, adaptation and development, and have launched programmes accordingly. The challenge, and it is an immense one, is to knit together a global response to urban needs and potentials, in which a wide variety of partners each contribute what they do best.

FUTURE POLICY DIRECTIONS

This section outlines some principles for policy development and discusses what policies should be considered at the international, national and local levels and, more briefly, by non-governmental partners, to strengthen planning and decision-making in urban areas in response to global climate change.

Principles for policy development

Several principles of policy development are fundamental to an integrated, multi-partner approach towards strengthened planning and decision-making in urban areas in response to global climate change:

- No single mitigation or adaptation policy is equally well-suited to all cities. Policy approaches should recognize and be sensitive to the diversity of urban areas worldwide.
- An opportunity/risk management approach in a sustainable development perspective should be encouraged: considering not only emissions but also risks that are present in a range of possible climate and socio-economic futures.
- Policies should emphasize, encourage and reward 'synergies' and 'co-benefits', i.e. what policies can do to achieve multiple objectives related to both development and climate change response goals.
- Climate change policies should address both near-term and longer-term issues and needs.
- Policies need to recognize the challenge of designing approaches that support multi-scale, multi-sector action in order to realize the differing and often complementary potentials of a wide range of partners.

International policies

There are three main areas in which the international community can support and enable more effective urban mitigation and adaptation responses:

- Financial resources need to be made more available to support the many vulnerable cities that need additional resources to respond to climate change. In particular, it is essential that action is taken to facilitate the use of the Adaptation Fund and the CDM for initiatives in urban areas.
- Bureaucratic burdens on local access to international support should be eased. The international community can help create direct communication and accountability channels between local actors and international donors, through intermediary organizations that can help disperse resources and monitor performance.
- Information of climate change science and options for mitigation and adaptation responses should be more widely available. The IPCC, the United Nations and other international organizations need to widen the spectrum of available knowledge on climate change.

National policies

National governments should use the following mechanisms to enable mitigation and adaptation actions at the local level:

- Design and implement national mitigation strategies and adaptation planning to support interventions by other stakeholders including local governments.
- Offer incentives such as tax rebates, tax exemptions and other incentives for investments in alternative energy sources, energy-efficient appliances, climate-proof infrastructures, houses and appliances, among other climate change mitigation and adaptation actions.
- Enhance coordination and streamlining between the dispersed actions of cities, sectors, regions and other parties in order to ensure that they are mutually reinforcing, rather than causing unexpected problems or conflicts in other contexts.
- Develop partnerships with non-governmental actors to share risks. For example, national governments can work with private insurance providers to offer

protection to cities without requiring each to make a sizeable investment in order to reduce risks from low-probability threats.
- Help cities to anticipate and plan for the possibility of much more substantial climate change impacts and adaptation needs in the longer term than those that are currently anticipated in the next decades.

City policies

In responding to climate change, urban policy-makers should begin from an awareness of local development aspirations and preferences, local knowledge of needs and options, local realities that shape choices, and local potentials for innovation. Urban authorities should:

- Develop a vision of where they want their future development to go and find ways to relate climate change responses to urban development aspirations.
- Expand the scope of community participation and action by representatives of the private sector, neighbourhoods (especially the poor) and grassroots groups, as well as opinion leaders of all kinds in order to ensure a broad-based collection of perspectives is gathered.
- Using an inclusive, participatory process, cities should conduct vulnerability assessments to identify common and differentiated risks to their urban development plans and their different demographic sectors, and identify ways to reduce those risks.
- Pay particular attention to the importance of adding climate-sensitive features to major infrastructure, especially when they are being designed, as the cost of adding these features will almost always be smaller before the infrastructure is built than they would after it is in place.

Policies of other partners

Governments do not, in isolation, determine appropriate responses to climate change in development contexts. To achieve more effective policies, local governments need to expand the scope, accountability and effectiveness of participation and engagement of NGOs such as community and grassroots groups, the academic sector, the private sector, and opinion leaders. This will serve multiple purposes:

- It will become a source of innovative options as well as both scientific and locally relevant knowledge.
- It will allow participants to understand and mediate the diverse perspectives and interests at play.
- It will provide a broad-based support for decisions and promote knowledge on the causes of emissions and vulnerabilities as well as mitigation and adaptation options thus achieved.

Partnerships with the private sector and NGOs are of special relevance in this context. For example:

- Resources from international, national and local private organizations can be mobilized to invest in the development of new technologies, housing projects and climate-proof infrastructures, and to aid in the development of climate change risk assessments.
- The widespread involvement of NGOs in climate arenas as diverse as climate awareness and education and disaster relief should be welcomed rather than making attempts to hold them outside these structures and interactions. The inputs and perspectives of these organizations can be harnessed to help develop a more integrated urban development planning.

Broad-based oversight organizations, such as advisory boards, representing the interests of all actors, should be created to help avoid the danger that private or sectarian interests may distort local action. Local action can be distorted, for example, by investment in technologies, infrastructures and housing that only benefit a minority, or by hijacking the benefits of grassroots funding. This is especially of concern in urban areas within countries that have experienced strong centralized control in the hands of local elites and state agents, but the principle of broad-based oversight can and should be practized everywhere.

CONCLUDING REMARKS

In summary, policy directions for linking climate change responses with urban development offer abundant opportunities; but they call for new philosophies about how to think about the future and how to connect different roles of different levels of government and different parts of the urban community. In many cases, this implies changes in how urban areas operate – fostering closer coordination between local governments and local economic institutions, and building new connections between central power structures and parts of the population who have often been kept outside of the circle of consultation and discourse.

The difficulties involved in changing deeply set patterns of interaction and decision-making in urban areas should not be underestimated. Because it is so difficult, successful experiences need to be identified, described and widely publicized as models for others. However, where this challenge is met, it is likely not only to increase opportunities and reduce threats to urban development in profoundly important ways, but to make the urban area a more effective socio-political entity, in general – a better city in how it works day to day and how it solves a myriad of problems as they emerge – far beyond climate change connections alone.

It is in this sense that climate change responses can be catalysts for socially inclusive, economically productive and environmentally friendly urban development, helping to pioneer new patterns of stakeholder communication and participation.

Cities must involve all stakeholders in responding to climate change

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