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Adapting to Climate Change in Urban Areas

The possibilities and constraints in low- and middle-income nations

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PREFACE

This paper is developed from a report commissioned by the Rockefeller Foundation to serve as a background paper for a discussion on Climate Change and Cities at the Foundation's Global Urban Summit, *Innovations for an Urban World*, in Bellagio in July 2007. The text draws heavily on a series of background papers that are acknowledged in the references; this paper incorporates sections of text drawn directly from these papers and so parts of the text are by Debra Roberts (case study on Durban's adaptation strategy), Jorgelina Hardoy and Gustavo Pandiella (background paper on Argentina), Karina Martínez, E. Claro and Hernando Blanco (background paper on Chile), Aromar Revi (background paper on India), Patricia Romero Lankao (background paper on Latin America), Cynthia B. Awuor, Victor A. Orindi and Andrew Adwerah (background paper on Mombasa), Mozaharul Alam (background paper on Bangladesh/Dhaka) and Sheridan Bartlett (background paper on the impacts of climate change on children)

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ABSTRACT: This paper discusses the possibilities and constraints for adaptation to climate change in urban areas in low- and middle-income nations. These contain a third of the world's population and a large proportion of the people and economic activities most at risk from sea-level rise and from the heatwaves, storms and floods whose frequency and/or intensity climate change is likely to increase. Section I outlines both the potentials for adaptation and the constraints, with section II discussing the scale of urban change. Section III considers direct and indirect impacts of climate change on urban areas and discusses which nations, cities and population groups are particularly at risk. This highlights how prosperous, well-governed cities can generally adapt, at least for the next few decades – assuming global efforts at mitigation successfully halt and then reverse global emissions of greenhouse gases. But most of the world's urban population lives in cities or smaller urban centres ill-equipped for adaptation – with weak and ineffective local governments and with very inadequate provision for the infrastructure and services needed to reduce climate-change-related risks and vulnerabilities. A key part of adaptation concerns infrastructure and buildings – but much of the urban population in Africa, Asia and Latin America has no infrastructure to adapt – no all-weather roads, piped water supplies or drains – and lives in poor-quality housing in floodplains or on slopes at risk of landslides. Most international agencies have long refused to support urban programmes, especially those that address these problems. Section IV discusses innovations by urban governments and community organizations and in financial systems that address such problems, including the relevance of recent innovations in disaster-risk reduction for adaptation. But it notes how few city and national governments are taking any action on adaptation. Section V discusses how local innovation in adaptation can be encouraged and supported at national scale, and the funding needed to support this. Section VI considers the mechanisms for financing this and the larger ethical challenges that achieving adaptation raises – especially the fact that most climate-change-related urban (and rural) risks are in low-income nations with the least adaptive capacity, including many that have contributed very little to greenhouse-gas emissions.

THE BIG ISSUES: A SUMMARY

Hundreds of millions of urban dwellers in low- and middle-income nations are at risk from the direct and indirect impacts of climate change. Without effective, locally driven adaptation, there will be very serious consequences for them and for national economies. However, there are limits to the damage or devastation that adaptation can prevent and also very serious deficiencies in the institutional capacities for urban adaptation in most low- and middle-income nations. This makes it all the more urgent that global agreements are reached to achieve the needed cuts in greenhouse gas emissions.

But there are very substantial synergies between successful adaptation to climate change and successful local development. Indeed, reductions in poverty, including improvements in housing and living conditions and in provision for infrastructure and services, are central to adaptation. Successful, well-governed cities greatly reduce climate-related risks for low-income populations; unsuccessful, badly governed cities do not and may greatly increase such risks.

Urban vulnerabilities. The scale of the devastation to urban populations and economies caused by extreme weather events in recent years highlights their vulnerabilities. Worldwide, there has been a rapid growth in the number of people killed or seriously impacted by storms and floods and also in the amount of economic damage caused; a large and growing proportion of these impacts are in urban areas in low- and middle-income nations. Climate change is likely to have been a factor in much of this, but even if it was not, it is proof of the vulnerability of urban populations to floods and storms whose frequency and intensity climate change is likely to increase in most places. Climate change will also bring other less dramatic stresses such as heat waves and, for many urban areas, reductions in freshwater availability; also sea-level rise for all coastal cities. Without major changes in the ways that governments and international agencies work in urban areas, the scale of these impacts will increase.

This report focuses on the vulnerability of urban populations in low- and middle-income nations to the direct and indirect impacts of climate change. This is for three reasons.

1. The scale of the population at risk. A large and growing proportion of those most at risk from climate change live in urban areas. More than a third of the world's ***total*** population lives in urban areas in low- and middle-income nations. These nations now have most of the world's urban population and most of the largest cities. Their urban centres will house most of the growth in the world's population over the next few decades and how this is planned for and managed has very large implications for the extent to which adaptation limits the costs of climate change.

Since 1950, there has been a sevenfold increase in the urban populations of low- and middle-income nations and a much-increased concentration of people and economic activities in low-lying coastal zones or other areas at risk from flooding and extreme weather events. Even Africa, long considered a rural continent, has two-fifths of its population in urban areas – and a larger urban population than Northern America. The last 50 years has also brought a very large increase in the number of urban dwellers living in poverty, lacking provision for the basic infrastructure and services that should protect them from environmental health hazards and disasters – and which should form the basis for protection from most impacts related to climate change. Around one billion urban dwellers live in poor-quality, overcrowded housing in "slums" or informal settlements, and a high proportion of these settlements are on sites at risk from flooding or landslides.

2. The economic costs without adaptation. Successful national economies depend on well-functioning and resilient urban centres. Urgent action is needed now both to address urban centres' current vulnerabilities to extreme weather and to build into expanding urban centres protection from likely future changes. Most buildings and infrastructure have long lives; what is built now needs to be able to cope with the climate change-induced risks over the next few decades. Ninety-nine per cent of households and businesses in low-income nations do not have disaster insurance.

3. The vulnerability of urban populations to climate change. Too little attention has been given to the vulnerability of urban populations to climate change – and especially to the vulnerability of their low-income populations. The need for more attention to this does not imply that rural populations' vulnerabilities should be given less attention; indeed, a high proportion of the people whose lives and livelihoods are most at risk from climate change are rural dwellers. But the growing literature on adaptation gives far more attention to agriculture and to rural livelihoods than to urban economies and

livelihoods. It is also inappropriate to consider rural and urban areas separately, given the dependence of urban centres on rural ecological services, the importance for many urban economies of rural demand for goods and services, and the reliance of much of the rural populations on urban centres for access to markets, goods and services.

The local nature of successful adaptation. Adaptation to climate change requires local knowledge, local competence and local capacity within local governments. It needs households and community organizations with the knowledge and capacity to act. It also requires a willingness among local governments to work with lower-income groups.

For most prosperous and well-governed cities, adaptation to the likely risks from climate change for the next few decades does not appear problematic. This centres on adapting buildings and infrastructure to these increased risks; working with population groups and settlements most at risk to find solutions that serve them; and good disaster preparedness. But you cannot adapt infrastructure that is not there. Hundreds of millions of urban dwellers have no all-weather roads, no piped water supplies, no drains and no electricity supplies; they live in poor-quality homes on illegally occupied or sub-divided land, which inhibits any investment in more resilient buildings and often prevents infrastructure and service provision. A high proportion are tenants, with very limited capacities to pay for housing – and their landlords have no incentive to invest in better-quality buildings. Most low-income urban dwellers face serious constraints in any possibility of moving to less dangerous sites, because of their need to be close to income-earning opportunities and because of the lack of alternative, well-located, safer sites.

Worldwide, many of the urban centres that need to adapt most to avoid serious (and potentially catastrophic) impacts have large deficiencies in all of these preconditions for successful adaptation – and for addressing the development deficiencies that underpin their lack of adaptation capacity. Most of the risk to urban populations is associated with the incapacity of local governments to ensure provision for infrastructure and for disaster risk reduction and disaster preparedness – or their refusal to work with the inhabitants of "illegal settlements", even when a third or more of the population (and workforce) live in these. This makes large sections of the urban population very vulnerable to any increases in the frequency or intensity of storms, floods or heat waves, and to increased risk of disease, constraints on water supplies or rises in food prices – which in wealthier, better-governed cities are usually easily adapted to. *You cannot fund a pro-poor adaptation strategy if the city government refuses to work with the poor, or sees their homes, neighbourhoods and enterprises as "the problem".* It is difficult to conceive of how to achieve the needed adaptation in the many nations that have weak, ineffective and unaccountable local governments; some also suffer from civil conflicts and have no economic or political stability. Building the needed competence, capacity and accountability within local governments in high-income nations was a slow, difficult, highly contested process that did not have to deal with climate change and that was much helped by prosperity and economic stability.

The vulnerability of low-income urban dwellers to climate change is often ascribed to their poverty – but it is far more the result of failures or limitations in local government. These in turn are linked to the failure of national governments and international agencies to support urban policies and governance systems that ensure needed infrastructure is in place, along with preparedness for extreme weather and, where needed, sea-level rise. Most international agencies have chosen to avoid investing in urban initiatives.

Building local capacity. Most national governments and international agencies have had little success in supporting successful local development in urban centres. They need to learn how to be far more effective in this and in supporting good local governance if they are to succeed in building adaptive capacity. Within international development assistance agencies, there may be a growing recognition of the importance of supporting "good governance" but this rarely focuses on the importance of good *local* governance. Even if it does, the institutional structures of most international agencies limit their capacity to support this. Meanwhile, the international agencies that are leading the discussions on how to support adaptation to climate change do not understand the political and institutional constraints on successful local adaptation. There is also a tendency to assume that as long as new funding sources for adaptation are identified, adaptation can take place.

Adaptation needs the attention of all sectors. There are clear and obvious linkages between adaptation to climate change and most other areas of development and environmental management.

Housing and infrastructure policies and housing finance systems that support better-quality housing and provision for water and sanitation (which has to include provision for drainage) is one key part of adaptation; achieving this will also require more competent, accountable urban governments. Addressing health issues means not only better health care available to all (which should include emergency response capacity for extreme weather events) but also reducing environmental health risks. This should also reduce many of the increased health risks that climate change is likely to bring. Adaptation also has to focus on what is needed to reduce the vulnerabilities of particular groups to particular aspects of climate change – for instance, the particular vulnerabilities of infants and children and their carers and of older age groups. This too needs more competent and accountable urban governments. For any growing urban centre, a large part of urban planning should focus on providing lower-income groups with safer, legal alternatives to informal settlements by increasing the supply and reducing the cost of land for housing, and supporting infrastructure on suitable sites. This too is at the core of city adaptation to changing risk patterns related to climate change. So too is the kind of land use management that protects and enhances natural buffers and defences for cities and their surrounds. Getting the needed collaboration and "joined-up-thinking" between so many different departments within national and local governments will be difficult.

Clearly, careful attention is needed in each nation and city to the contributions that private enterprises and investments can make to adaptation. This obviously includes more attention to adapting their own premises. It also includes the many enterprises that can offer goods and services that help individuals, households and governments adapt. Extending appropriate financial services to lower-income groups can help them save and invest in safer homes and better livelihoods, all of which generally increases adaptive capacity. Insurance can also protect households and enterprises – and if appropriately structured, encourage risk reduction. But care is needed not to overstate the potential. Climate change will increase risks and most of those who face the most serious risks have very limited incomes. If local governments do not act to reduce risks, insurance premiums will be unaffordable – or no insurance will be on offer. Most of the financial safety nets that work for low-income groups are ones they set up and manage themselves. The potential of private sector investments and public–private partnerships to address urban development issues has long been overestimated; there is a danger that it will also be overstated for funding adaptation. An analysis of private investment flows into urban areas in low- and middle-income nations shows their potential to help fund some forms of infrastructure improvement and adaptation – but not the infrastructure most in need of improvement and adaptation, and not in most of the nations and cities where adaptation is most urgently needed.

Local precedents show possibilities – and constraints. There are innovative urban policies and practices underway, which show that adaptation is possible and can be built into development plans. These include examples of community-based initiatives led by organizations formed by the urban poor that greatly reduce their vulnerability to storms and floods – at very low unit cost. There are also good examples of local governments working in partnership with their low-income populations to improve housing conditions and infrastructure provision, or to develop new good-quality settlements. These include many partnerships between local governments and federations formed by slum and shack dwellers. There are also more post-disaster responses that recognize the competence and capacity of those displaced to rebuild their lives, including their homes and livelihoods – if the organizations that respond to the disaster allow them to do so.

But these are the exceptions. Few government bodies or international agencies recognize the competence and capacity within the populations they identify as "most at risk". What is needed is consideration of how local ***development+adaptation*** innovations, comparable to those noted above, can be encouraged and supported in many more places. This is not replication, because each urban centre needs adaptation that responds to particular local conditions and capacities and that overcomes particular local constraints.

There are nations where the competence and accountability of city and municipal governments have increased considerably, providing the needed adaptive capacity – but most are in middle-income nations. And even here, it is difficult to get much attention to climate change adaptation from city governments and most national ministries and agencies within their urban policies and investments. Most have more pressing issues, including large backlogs in provision for infrastructure and services, and many urban dwellers living in poor-quality housing. They are also under pressure to improve education, health care and security – and seek ways to expand employment and attract new investment. *Even competent and accountable national and local (city and municipal) governments will not engage with adaptation to climate change unless it is seen as supporting and enhancing the achievement of development goals.*

There is also the important shift underway in many agencies that focus on disasters away from disaster response to disaster preparedness and disaster risk reduction. This has great relevance for adaptation to climate change but, as yet, this has not influenced many city and national policies.

Global issues. Those discussing adaptation must remember the profound unfairness that exists globally between those who cause climate change and those who are most at risk from its effects. With regard to people, it is the high-consumption lifestyles of the wealthy (and the production systems that meet their consumption demands) that drive climate change, but it is mostly low-income groups in low- and middle-income nations, with negligible contributions to climate change, that are most at risk from its impacts. With regard to nations, the very survival of some small-island and some low-income nations (or their main cities) is in doubt, as much of their land area is at risk from sea-level rise, even though they have contributed very little to the global warming that drives it. With regard to cities, most larger companies and corporations can easily adjust to the new patterns of risk induced by climate change, and they move their offices and production facilities away from cities at risk. But cities cannot move. And all cities have within them the homes, cultural and financial assets and livelihoods of their inhabitants, much of which cannot be moved.

What will happen to international relations as increasing numbers of people lose their homes, assets, livelihoods and cultural heritages to climate change-related impacts – especially when the main causes of this are strongly associated with the lifestyles of high-income groups in high-income nations, and the reason for their loss is the failure of high-income nations to cut back their emissions?

What needs to be done? The key issue is how to build, in tens of thousands of urban centres, resilience to the many impacts of climate change that:

- **supports and works with the reduction of risks to other environmental hazards, including disasters** (there are strong complementarities between reducing risk from climate change, non-climate change-related disasters and most other environmental hazards);
- **is strongly pro-poor** (most of those most at risk from climate change and from other environmental hazards have low incomes, which limits their autonomous adaptive capacity);
- **builds on the knowledge acquired over the last 20 years on reducing risks from disasters in urban areas** (there have been important advances here);
- **is based on and builds a strong *local* knowledge base** of climate variabilities and of the likely local impacts from climate change scenarios;
- **encourages and supports actions that reduce risks (and vulnerabilities) now, while recognizing the importance of measures taken now to begin the needed long-term changes –** urbanization processes have a momentum and drivers that are difficult to change, but at present these are mostly increasing risks from climate change and so can be considered mal-adaptation;
- **recognizes that the core of the above is building the competence, capacity and accountability of city and sub-city levels of government and is changing their relationship with those living in informal settlements and working in the informal economy** – and the importance within this of supporting civil society groups, especially representative organizations of the urban poor (this is also to avoid the danger of "adaptation" providing opportunities for powerful groups to evict low-income residents from land they want to develop);
- **recognizes that government policies must encourage and support the contributions to adaptation of individuals, households, community organizations and enterprises**;
- **recognizes the key complementary roles required by higher levels of government and international agencies to support this** (and that this requires major changes in policy for most international agencies that have long ignored urban issues and major changes in how adaptation is funded);
- **builds resilience and adaptation capacity in rural areas** – given the dependence of urban centres on rural production and ecological services and the importance for many urban economies and enterprises of rural demand for (producer and consumer) goods and services; and also
- **builds into the above a mitigation framework** (if successful cities in low- and middle-income nations develop without this, global greenhouse gas emissions cannot be reduced).

Two final points. First, it is inappropriate to conceive of "the problem" as mainly one of a lack of funding. Certainly, new funding sources are required to address backlogs in infrastructure and services and to build adaptive capacity. But, for most urban centres, the problem is as much a lack of local government competence and capacity. The need to adapt is being forced onto nations and cities that lack the political and economic basis for adaptation, even if new funding is provided. Within discussions on climate-change adaptation, there is too much focus on trying to calculate the funding needed for adaptation without recognizing the political and institutional constraints on adaptive capacity and without discussing the institutional mechanisms to get the needed funding for adaptation to those who can use it well – including community-based or grassroots-led initiatives.

Second, NAPAs (National Adaptation Programmes of Action) need to be built from city-focused CAPAs (City Adaptation Programmes of Action) and locally focused LAPAs (Local Adaptation Programmes for Action). Risks and vulnerabilities in all aspects of climate change are shaped by local contexts and much influenced by what local governments do or do not do. In the end, almost all adaptation is local and, to be effective, needs strong local knowledge and strong local adaptive capacity. Certainly for urban areas, there need to be CAPAs and, very often, smaller-scale LAPAs – especially for the settlements or areas most at risk. These, in turn, can also promote learning and innovation on how public policies and investments can work best with community-based adaptation. They also provide the practical experience on which NAPAs can be much improved.

I. INTRODUCTION

The lives and livelihoods of hundreds of millions of people will be affected by what is done (or not done) in urban centres in regard to climate change over the next 5–10 years. Urban centres are key players both in the generation of greenhouse gases and in strategies to reduce this generation, especially in reducing dependence on carbon-based fuels.[1] They also concentrate a large proportion of those most at risk from the effects of climate change – and the enterprises that generate most of the world's GDP. While the need for city and municipal governments and civil-society groups to act to reduce greenhouse-gas emissions is well established – and with many city governments in Europe and North America and some in other regions already acting on this – the need to act to reduce urban residents' vulnerability to the many direct and indirect impacts of climate change is not. In addition, most of the urban centres (and nations) that face the highest risks from the negative effects of climate change are those with almost negligible contributions to the greenhouse gases in the atmosphere; most also have serious constraints on their adaptive capacity.

The potentials for adaptation

As the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) notes, urban centres and the infrastructure they concentrate – and the industries that are a key part of many such centres' economic base – are often capable of considerable adaptation to reduce risks from the direct and indirect impacts of climate change.[2] All large urban centres have had to make very large "adaptations" to environmental conditions, site characteristics, natural-resource availabilities and environmental hazards to be able to function as urban centres – for instance creating stable sites for buildings, putting in place the infrastructure that all cities require and ensuring provision for water and for managing wastewater and storm and surface runoff. Successful and healthy cities are proof of the adaptation capacities of their governments, citizens and enterprises. In any well-governed city, there is already a great range of measures in place to ensure that buildings and infrastructure can withstand extreme weather events and that water-supply systems can cope with variations in freshwater supplies. Good environmental and public health services should also be able to cope with any increase in other climate-change-related health risks in the next few decades – whether this is through heatwaves or reduced freshwater availability, or greater risks from communicable diseases.

Thus, it is easy to envisage a process by which urban planning and management ensures planned adaptation – with developments and investments in and around each urban area reducing risks for inhabitants, enterprises and infrastructure to climate-change-related impacts. So, over time, this adapts the building-stock, the industrial base, the infrastructure and the spread of urban development to the risks these changes bring. The tools and methods required to do this are well known and their effectiveness has been demonstrated in many locations – for instance, adjustments to building codes, land-subdivision regulations and infrastructure standards combined with land-use planning that restricts buildings in high-risk areas and makes special provision for extreme events including the use of insurance to spread risk. Also necessary is an inventory of industries and other activities with the potential to cause serious secondary problems (such as fire or chemical contamination) when a disaster happens. There is a well-established literature on the importance of integrating adaptation into disaster-preparedness in and around urban areas. For large, well-established cities, there are often particular problems with adjusting existing buildings, infrastructure and land-use patterns to the new or heightened risks that climate change will or may bring, but these can generally be addressed by long-term policies which make these affordable by spreading the cost over long periods and by making use of potential synergies between reducing climate-change risks and reducing other environmental risks. Most of the risks from climate change heighten other risks already present.

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[1] Romero Lankao, Patricia (2007), "Are we missing the point? Particularities of urbanization, sustainability and carbon emissions in Latin American cities", *Environment and Urbanization*, Vol. 19, No. 1, pages 157–175.

[2] Wilbanks, Tom and Patricia Romero Lankao with Manzhu Bao, Frans Berkhout, Sandy Cairncross, Jean-Paul Ceron, Manmohan Kapshe, Robert Muir-Wood and Ricardo Zapata-Marti (2007), Chapter 7: *Industry, Settlement and Society*, in Parry, Martin, Osvaldo Canziani, Jean Palutikof, Paul van der Linden and Clair Hanson (editors) *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, pages 357-390.

In addition, all low-income and most middle-income nations have what might be considered an advantage in that much of their "urbanization" is to come in the next few decades and, since it has not happened yet, it can be planned and managed in ways that accommodate the increased risks that climate change is likely to bring. This can include measures to channel new urban growth away from high-risk sites – for instance from cities or city-sites at high risk of moderate sea-level rises and storm surges. There are some particular worries in regard to the impact of the needed measures on housing and basic services for low-income groups: higher building and infrastructure standards and land-use restrictions (including avoiding new constructions on floodplains) could mean rising land and housing prices and much-reduced supplies of cheap accommodation – but special measures can be taken to ensure sufficient supplies of well-located, serviced land for new housing. It is also easy to envisage this process addressing hazards unrelated to climate change – for instance improved drainage and provisions for coping with occasional heavy, concentrated rainfall that has long been a risk (and often produces serious flooding). So adaptation to climate change is integrated into programmes to reduce risks from disasters and other environmental hazards. It is also easy to envisage this process incorporating measures that reduce greenhouse-gas emissions. There is evidence from some cities in low- and middle-income nations of the kinds of discussions within their governments on what local adaptations may be needed that can underpin good long-term planning for and investment in adaptation – as in Durban, South Africa, for instance, as described below.

Thus, when problems of urban areas' adaptation to climate change are considered, independent of current conditions and government structures, it is easy to map out a long-term process of support and funding for adaptation. At least in the next fifty years or so, assuming none of the high-impact but uncertain catastrophic climate changes take place, this seems able to produce the needed adaptations without high costs in most locations. Certain cities face far more serious risks than others, but it is possible to envisage an international funding system that gives special attention to helping them adapt. It is also possible to envisage national adaptation strategies that encourage and support urban development away from the areas most at risk from climate-change-related impacts. Most governments and many international agencies have officially endorsed recommendations to move in this direction – as in, for instance, the Hyogo Framework for Action 2005–2015 or the Habitat Agenda, that came out of the second UN Conference on Human Settlements in 1996.

The constraints on implementation

It would be a mistake to assume that the above – a logical, justifiable, fundable process driven by good science – provides a viable roadmap for action. The examples of evolving good practice in this paper represent exceptions, and it is important to understand why this is so. It is easy for national governments to sign declarations at international conferences that recommend all the needed measures – and then ignore them.

The best indication of the constraints on implementing adaptation comes from the last 50–60 years of "development". In the 1950s, it was easy to envisage a process by which international funding for "productive activities" and the required infrastructure allied to "technical assistance" would rapidly reduce poverty and "under-development" in Africa, Asia and Latin America and the Caribbean. Yet, more than five decades later, the number of people suffering extreme poverty is much larger than it was in the 1950s. Indeed, there was a need to launch the Millennium Development Goals in 2000 precisely to focus attention on the vast scale of unmet needs, despite four "development decades". In the 1970s, many international agencies committed themselves to a new focus on "meeting basic needs", with detailed costings of what additional funding this would require; four decades later, the number of people lacking access to most "basic needs" is higher than it was in the 1970s. Today, there are more urban dwellers living in very poor-quality, overcrowded housing lacking basic infrastructure and services in low- and middle-income nations than their entire urban population in 1975.[3]

[3] Recently released World Bank statistics suggest that the proportion of people that are poor fell between 1990 and 2004, in Africa and Latin America and the Caribbean, even if the number increased; for Asia, the number and the proportion were reported to have fallen. But this is using the widely discredited "$1 a day" poverty line; for large sections of the urban population, this is an inappropriate poverty line because the cost of basic non-food necessities

Most cities in low- and middle-income nations have much of their physical growth and economic expansion taking place outside any official plan and outside official rules and regulations. Most new housing is also built outside these. In part, this is because large sections of the population could never afford a house that met official standards (and often the standards are unrealistic and their implementation cumbersome and costly). In part, it is because of a very large mismatch between the growth of urban centres' economic bases and populations and the competence, capacity and accountability of local government structures. There are important exceptions, as described below – but they are exceptions. These might be held up as examples of "best practice", but the political and economic circumstances that underpinned their good practice are rarely transferable.

In urban centres in Africa, Asia and Latin America and the Caribbean, over 900 million people live in accommodation that is of poor quality (with particular problems in relation to poor-quality structures, overcrowding, insecure tenure and inadequate provision for water, sanitation and drainage).[4] One other indication of the scale of urban problems is the number of people living in illegal settlements because they cannot afford to buy, build or rent legal accommodation. High proportions of urban dwellers living in informal settlements has become the norm in urban areas, not the exception; it is common for cities to have 30–50 per cent of their entire population living in settlements that developed illegally.[5] Estimates for 2000 suggested that more than 680 million urban dwellers lacked adequate provision for water and 850 million or more lacked adequate provision for sanitation.[6] Statistics on infant and child mortality rates for urban populations show that these are often 5–20 times what they should be, if families had adequate incomes, reasonable-quality housing and good health care.[7] There are also many case studies focusing on low-income urban populations that show very large health burdens from diseases that should be easily prevented or cured – for instance diarrhoeal diseases, intestinal parasites, tuberculosis, malaria, dengue fever and acute respiratory infections.

There is not much point in discussing how city or municipal governments can adapt to protect the populations within their jurisdiction from risks arising from climate change when they have shown so little inclination or ability to protect them from other environmental hazards. There are really two separate issues here, although they often act together. The first issue is the incapacity of urban governments in terms of their powers and the resources at their disposal, and this in turn relates to the refusal of higher levels of governments to allow them the powers and resources they require to address local needs, and to the long-established disinterest among most international agencies in supporting urban development and urban governance reforms.[8] The second issue is the antagonistic relationship between urban governments and most low-income groups; this also relates to urban governments' lack of accountability to their urban populations, but it goes beyond this. It is strongly reinforced by urban elites' visions of what they see as a modern city, and by real-estate interests wanting access to land currently occupied by informal settlements. The urban poor are not seen as critical parts of the city economy but as holding back the city's success. Official urban policies so often increase poor people's vulnerability to environmental hazards and climate shocks, rather than reducing them[9] – and so they are best conceived as maladaptation.

There is also not much point in discussing how to adapt urban planning and its regulatory framework to

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is significantly higher than this; see Satterthwaite, David (2004), *The Under-estimation of Urban Poverty in Low and Middle-Income Nations*, IIED Working Paper, IIED, London, 69 pages.

[4] UN-Habitat (2003), *The Challenge of Slums: Global Report on Human Settlements 2003*, Earthscan, London.

[5] Ibid.

[6] UN-Habitat (2003), *Water and Sanitation in the World's Cities: Local Action for Global Goals*, Earthscan, London.

[7] For a review of infant and child mortality rates in urban areas, drawing on the Demographic and Health Surveys, see Satterthwaite, David (2007), "In pursuit of a healthy urban environment in low- and middle-income nations" in Marcotullio, Peter J. and Gordon McGranahan (editors), *Scaling Urban Environmental Challenges: From Local to Global and Back*, Earthscan, London, pages 69–105.

[8] See for instance Satterthwaite, David (2001), "Reducing urban poverty: constraints on the effectiveness of aid agencies and development banks and some suggestions for change", *Environment and Urbanization*, Vol. 13, No. 1, pages 137–157; and Tannerfeldt, Goran and Per Ljung (2006), *More Urban, Less Poor; An Introduction to Urban Development and Management*, Earthscan and Sida, London, 190 pages.

[9] Hardoy, Jorge E., Diana Mitlin and David Satterthwaite (2001), *Environmental Problems in an Urbanizing World: Finding Solutions for Cities in Africa, Asia and Latin America*, Earthscan, London, 448 pages.

reduce people's vulnerability to climate change when planning and regulation enforcement will only serve those with power and be used to evict and dispossess poorer groups, whenever it serves those in power to do so. Tens of millions of urban dwellers are forcibly evicted from their homes each year – mostly without compensation, or with inadequate or inappropriate compensation.[10]

Many factors helped to create this – for instance, in most urban centres, the unrealistic minimum standards demanded for housing and plot-sizes. Many standards in sub-Saharan Africa and Asia are still based on regulations created under colonial rule and originally instituted for use only within areas of the colonial city that were inhabited by "non-natives". Under colonial rule, these were never seen as measures to be implemented for entire city populations. But the issue is not that these regulations are inappropriate, but that they are still used because they serve the interests of those in power. The mechanisms for their enforcement are also often expensive – and open to corrupt practices. Ironically, poverty may be lower in cities where regulations are not enforced than where inappropriate regulations are enforced. For any growing city, what is worse than expanding "squatter settlements" is government authorities preventing squatter settlements – which will mean poor families doubling and tripling up within the existing housing stock.

Land-use planning and regulations in any city influence the supply of land for housing. They can act to reduce or increase the price and availability of legal housing because of their influence on the price and availability of land with infrastructure and services. Thus, how land-use planning measures respond to climate-change risks has very large implications for the possibilities of low- and middle-income households to buy, build or rent good-quality, legal accommodation with infrastructure in areas that are not at risk from floods or landslides. Where governments have the competence and capacity to support locally appropriate land-for-housing development and subdivision regulations, this improves housing conditions and greatly widens housing possibilities for low-income households – as seen in, for instance, in the cities of Ilo in Peru and Windhoek in Namibia (whose innovations are described below). But these are the exceptions, as are the political conditions that produced them.

Climate change and other risks

It makes no sense to discuss the vulnerability of urban populations to climate change and responses to it separate from their vulnerability to extreme weather events or disasters that are not caused by climate change. The Asian Tsunami of 2004 demonstrated the vulnerability of so many coastal cities (or of specific populations within them) to the risk of flooding and storm surges, even if it was not caused by climate change. The same is true for most of the devastating floods that many cities have experienced in the last 10–15 years. The key here is to understand how the processes that shape urbanization create or exacerbate risk to a range of hazards, including those that climate change will introduce or is likely to increase. This can also draw on a good, new literature identifying "risk-accumulation processes" with current patterns of urban development – and the need to shift attention from "disasters"/events to the processes that created or exacerbated the risks, and how these can be acted on.

In addition, we cannot consider the "adaptation" that cities such as Mumbai must make in regard to climate change independent of the fact that nearly half the population lives in "slums" lacking sewers and drainage infrastructure – and regular solid-waste collection systems (so that garbage blocks the drains). Central to any discussion of a city population's vulnerability to climate change is a discussion of how and why city authorities refuse to (or are not allowed to) invest in infrastructure and services in "slums" or informal settlements. **We end up with a discussion of the vulnerability of city populations and of specific groups within them to environmental hazards – including extreme weather events, floods and water shortages – and of how climate change is likely to increase, extend or change this.**

[10] For a summary, see du Plessis, Jean (2005), "The growing problem of forced evictions and the crucial importance of community-based, locally appropriate alternatives", *Environment and Urbanization*, Vol. 17, No. 1, pages 123–134.

Box 1: Definitions of terms

Adaptation to (human-induced) climate change: Actions to reduce the vulnerability of a system (e.g. a city), population (e.g. a vulnerable population in a city) or individual to the adverse impacts of anticipated climate change due to emission of greenhouse gases. In this paper, vulnerability is applied only to people or collections of people (e.g. the population of an urban area). Adaptation to climate variability consists of actions to reduce vulnerability to short-term climate shocks (with or without climate change). Often adaptation to climate change will also result in adaptation to climate variability as well (as a co-benefit). However, individual adaptation can undermine collective resilience or compromise collective adaptive capacity.

Adaptive capacity: Inherent capacity of a system (e.g. a city government), population (e.g. low-income community in a city) or individual/household to undertake actions that can help avoid loss and speed recovery from any impact of climate change. Elements of adaptive capacity include knowledge, institutional capacity and financial and technological resources. Low-income populations in a city will tend to have lower adaptive capacity than the rich/high-income population. There is also a wide range among city and national governments in their adaptive capacities, relating to the resources available to them, the information base to guide action, the infrastructure in place and the quality of their institutions and governance systems.

Adaptation deficit: Lack of adaptive capacity to deal with the problems of climate variability (let alone any future climate-change impacts). In many cities and most smaller urban centres, the main problem is the lack of provision for infrastructure (such as all-weather roads, piped water supplies, sewers, drains and electricity) and the lack of capacity to address this. This is one of the central issues in regard to adaptation because most discussions on this issue focus on adjustments to infrastructure – but you cannot climate-proof infrastructure that is not there. Funding for “adaptation” has little value if there is no local capacity to design, implement and maintain the needed adaptation.

Adaptation and mitigation linkages: Mitigation (i.e. the reduction of greenhouse-gas emissions) results in avoiding the adverse impacts of climate change in the long run (at least the incremental impacts due to the greenhouse gases not emitted), while adaptation can reduce the unavoidable impacts in the near term (but cannot reduce them to zero). Failure to mitigate will lead eventually to failure of adaptation, hence adaptation and mitigation are not alternative strategies but complementary ones that need to be pursued together. But, as this paper discusses, most of the people and places at greatest risk from climate change are not those with large historic or current contributions to greenhouse gases. Failure to mitigate sufficiently in high-income nations will create ever more adaptation failures, mostly in low- and middle-income nations, including many with insignificant contributions to climate change. The political consequences of this will obviously be enormous.

Adaptation in situ: Actions that enable vulnerable populations to adapt successfully to climate change (and climate variability), including adaptations made or supported by local governments. In most instances, vulnerable urban populations would prioritize in-situ adaptation because their current home and location was chosen for its access to income-earning opportunities.

Autonomous adaptation: Adaptations that occur without any specific planning (e.g. by companies or individuals).

Climate-change risk: Additional risks to people and their livelihoods/investments (e.g. buildings, infrastructure) due to the potential impacts of climate change. These risks can be direct, as in larger and/or more frequent floods, or more intense and/or frequent storms, or heatwaves, or less direct as climate change negatively affects livelihoods or food supplies (and prices) or access to water needed for domestic consumption or livelihoods. Certain groups may face increased risks from measures taken in response to climate change – including adaptation measures (for instance, measures to protect particular areas of a city from flooding which increase flood-risks “downstream”) and mitigation measures (for instance, emphasis on new hydropower schemes that displace large numbers of people).

Limits to adaptation: Adaptation can reduce the adverse impacts of climate change considerably but cannot reduce them to zero. Thus, there are limits to adaptation. Also, certain places become permanently beyond adaptation (e.g. coastal zones inundated by sea-level rise), and the number of these places (and the populations at risk) obviously rises without successful mitigation.

Maladaptation: Actions or investments that enhance rather than reduce vulnerability to impacts of climate change. This can include the shifting of vulnerability from one social group or place to another; it also includes shifting risk to future generations and/or to ecosystems and ecosystem services. In many cities, investments being made are in fact maladaptive rather than adaptive. Removing maladaptations is often the first task to be addressed even before new adaptations.

Planned adaptation: Adaptations that are planned in anticipation of potential climate change. Generally, government agencies have key roles in providing the information about current and likely future risks, and providing frameworks that support individual, household, community and private-sector adaptation. However, governments often do not fulfil this role, and civil-society organizations may instead be the initiators and supporters.

Resilience: Resilience is a product of governments, enterprises, populations and individuals with strong adaptive capacity. It indicates a capacity to maintain core functions in the face of hazard threats and impacts, especially for vulnerable populations. It usually requires a capacity to anticipate climate change and plan needed adaptations. An entity's resilience to climate change and variability interacts with its resilience to other dynamic pressures including economic change, conflict and violence.

II. BACKGROUND

The dimensions of urban change

The scale of urbanization[11]

Urban areas in low- and middle-income nations have more than a third of the world's total population, nearly three-quarters of its urban population and most of its large cities. They contain most of the economic activities in these nations and most of the new jobs created over the last few decades. They are also likely to house most of the world's growth in population in the next 10–20 years.[12] In regard to climate change, they already house a large proportion of the population and the economic activities most at risk from extreme weather events and sea-level rise – and this proportion is increasing.

Half of the world's current population of around 6.4 billion people lives in urban centres,[13] compared to less than 15 per cent in 1900.[14] Many aspects of urban change in recent decades are unprecedented, including not only the world's level of urbanization and the size of its urban population, but also the number of countries becoming more urbanized and the size and number of very large cities. The populations of dozens of major cities have grown more than ten-fold in the last 50 years, and many have grown more than twenty-fold.[15] There are also the large demographic changes apparent in all nations over the last 50 years that influence urban change, including rapid population growth rates in much of Latin America, Asia and Africa after the Second World War (although in most cases these have declined significantly), and changes in the size and composition of households and in age structures.[16]

Table 1 shows the scale of urban population growth since 1950. Asia now has close to half the world's urban population, and Africa has a larger urban population than Northern America or Western Europe, even though it is often perceived as overwhelmingly rural. In 1950, Europe and Northern America had more than half the world's urban population; by 2000, they had little more than a quarter.

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[11] The analysis of urban change and its drivers in this paper is a summary drawn from Satterthwaite, David (2007), *The Transition to a Predominantly Urban World and its Underpinnings*, IIED Working Paper, 90 pages. This is the latest in a series of reviews of urban change and its causes that this author's Institute has undertaken since the early 1980s. All have drawn heavily on data provided by the United Nations Population Division, supplemented with reviews of census data.

[12] United Nations (2006), *World Urbanization Prospects: The 2005 Revision*, United Nations Population Division, Department of Economic and Social Affairs, CD-ROM Edition – Data in digital form (POP/DB/WUP/Rev.2005), United Nations, New York.

[13] According to the most recent United Nations statistics, the transition to more than half the world's population living in urban areas will occur in 2008. However, it may be that the world became more than half urban some years ago. Many cities under-count their populations, excluding those living in illegal settlements. Many governments deliberately understate their urban populations by classifying most small urban centres as rural – see Satterthwaite (2007), *The Transition to a Predominantly Urban World,* op. cit.

[14] Graumann, John V. (1977), "Orders of magnitude of the world's urban and rural population in history", *United Nations Population Bulletin 8,* United Nations, New York, pages 16–33.

[15] Satterthwaite (2007), *The Transition to a Predominantly Urban World,* op. cit.

[16] See Montgomery, Mark R., Richard Stren, Barney Cohen and Holly E. Reed (editors) (2003), *Cities Transformed; Demographic Change and its Implications in the Developing World*, The National Academy Press (North America)/ Earthscan (Europe), Washington DC, 518 pages.

Table 1: The distribution of the world's urban population by region, 1950–2010

Region or country	1950	1970	1990	2000*	Projected for 2010
Urban populations (millions of inhabitants)					
WORLD	732	1,329	2,271	2,845	3,475
High-income nations	423	650	818	874	922
Low- and middle-income nations	309	678	1,453	1,971	2,553
"Least developed nations"	15	41	110	166	247
Africa	33	85	203	294	408
Asia	234	485	1,011	1,363	1,755
Europe	277	411	509	522	529
Latin America and the Caribbean	70	163	315	394	474
Northern America	110	171	214	249	284
Oceania	8	14	19	22	25
Urbanization level (percentage of population living in urban areas)					
WORLD	29.0	36.0	43.0	46.7	50.8
High-income nations	52.1	64.6	71.2	73.2	75.2
Low- and middle-income nations	18.1	25.2	35.2	40.3	45.5
"Least developed nations"	7.3	13.1	21.0	24.7	29.0
Africa	14.7	23.4	32.0	36.2	40.5
Asia	16.8	22.7	31.9	37.1	42.5
Europe	50.5	62.6	70.6	71.7	72.9
Latin America and the Caribbean	42.0	57.2	70.9	75.4	79.1
Northern America	63.9	73.8	75.4	79.1	82.1
Oceania	62.0	70.8	70.3	70.5	71.2
Percentage of the world's urban population living in:					
WORLD	100.0	100.0	100.0	100.0	100.0
High-income nations	57.8	49.0	36.0	30.7	26.5
Low- and middle-income nations	42.2	51.0	64.0	69.3	73.5
"Least developed nations"	2.0	3.1	4.8	5.8	7.1
Africa	4.5	6.4	8.9	10.3	11.7
Asia	32.0	36.5	44.5	47.9	50.5
Europe	37.8	30.9	22.4	18.4	15.2
Latin America and the Caribbean	9.6	12.3	13.9	13.9	13.6
Northern America	15.0	12.9	9.4	8.8	8.2
Oceania	1.1	1.0	0.8	0.8	0.7
Nations with largest urban populations in 2000					
China	9.9	10.9	13.9	16.0	17.5
India	8.3	8.3	9.6	9.9	10.3
USA	13.8	11.6	8.5	7.9	7.4
Brazil	2.7	4.0	4.9	5.0	4.9
Russian Federation	6.2	6.1	4.8	3.8	2.9

* The statistics for 2000 are an aggregation of national statistics, many of which draw on national censuses held in 1999, 2000 or 2001 – but some are based on estimates or projections from statistics drawn from censuses held around 1990. There are also some nations (mostly in Africa) for which there are no census data since the 1970s or early 1980s so all figures for their urban (and rural) populations are based on estimates and projections.

SOURCE: Satterthwaite, David (2007), *The transition to a predominantly urban world and its underpinnings*, IIED Working Paper, 90 pages. The figures are drawn or derived from statistics in United Nations (2006), *World Urbanization Prospects: the 2005 Revision*, United Nations Population Division, Department of Economic and Social Affairs, CD-ROM Edition – Data in digital form (POP/DB/WUP/Rev.2005), United Nations, New York.

The growth of large cities

Two aspects of the rapid growth in the world's urban population since 1950 are the increase in the number of large cities and the historically unprecedented size of the largest cities. Just two centuries ago, only two cities had more than a million inhabitants – London and Beijing (then called Peking). By 1950, there were 75 "million-cities"; and by 2000 there were 380, with most in low- and middle-income nations. The size of the world's largest cities has also increased dramatically. In 2000, the average size of the world's 100 largest cities was around 6.3 million inhabitants, compared to 2.0 million inhabitants in 1950 and 0.7 million in 1900.[17] While there are examples of cities over the last two millennia that had populations of one million or more inhabitants, the city or metropolitan area with several million is a relatively new phenomenon – London being the first to reach this size in the second half of the 19th century.[18] By 2000, there were 45 cities with more than 5 million inhabitants.

Table 2: The distribution of the world's largest cities by region over time

Region	1800	1900	1950	2000
Number of "million cities'				
World	2	17	75	380
Africa	0	0	2	37
Asia	1	4	28	192
China	1	2	12	86
India		1	5	32
Europe	1	9	22	53
Latin America and the Caribbean	0	0*	7	51
Northern America	0	4	14	41
USA		4	12	37
Oceania	0	0	2	6
Regional distribution of the world's largest 100 cities				
World	100	100	100	100
Africa	5	2	3	8
Asia	64	22	42	49
China	23	13	18	17
India	19	4	6	8
Europe	28	53	26	10
Latin America and the Caribbean	3	5	8	16
Northern America	0	16	19	15
USA	0	15	17	13
Oceania	0	2	2	2
Average size of the world's 100 largest cities (population)	184,270	726,350	2,000,000	6,300,000

* Some estimates suggest that Rio de Janeiro had reached 1 million inhabitants by 1900.

NOTES: Cities that have changed their country-classifications and nations that have changed regions are considered to be in the country or region that they are currently in for this whole period. For instance, Hong Kong is counted as

[17] Satterthwaite (2007), *The Transition to a Predominantly Urban World,* op. cit.
[18] Chandler, Tertius and Gerald Fox (1974), *3000 Years of Urban Growth*, Academic Press, New York and London.

being in China for all the above years, while the Russian Federation is considered part of Europe. Some figures for city populations for 2000 are based on estimates or projections from statistics drawn from censuses held around 1990. There is also a group of countries (mostly in Africa) for which there is no census data since the 1970s or early 1980s, so all figures for their city populations are based on estimates and projections. The regional distribution of cities in 1950 and 2000 is, in part, influenced by how cities/ urban agglomerations are defined within nations.

SOURCES: Satterthwaite, David (2007), *The transition to a predominantly urban world and its underpinnings*, IIED Working Paper, 90 pages. For 1950 and 2000, the figures are drawn or derived from statistics in United Nations (2006), *World Urbanization Prospects: the 2005 Revision*, United Nations Population Division, Department of Economic and Social Affairs, CD-ROM Edition – Data in digital form (POP/DB/WUP/Rev.2005), United Nations, New York. For 1900 and 1800, data came from an IIED database with census data and estimates for city populations drawn from a great range of sources, including Chandler, Tertius and Gerald Fox (1974), *3000 Years of Urban Growth*, Academic Press, New York and London; Chandler, Tertius (1987), *Four Thousand Years of Urban Growth: An Historical Census*, Edwin Mellen Press, Lampeter, UK, 656 pages; and Showers, Victor (1979), *World Facts and Figures*, John Wiley and Sons, Chichester, 757 pages. For Latin America, it also drew on a review of 194 published censuses.

Vulnerability and resilience

Understanding vulnerability

There are many examples throughout history of city populations, enterprises and governments adapting to unfavourable or even extreme environments. This shows the considerable capacity to adapt to known conditions, given economic and human resources and access to knowledge.[19] This also implies the potential to adapt to many aspects of climate change, especially the more gradual changes. However, many urban centres are at risk from the kinds of extreme weather events that climate change is likely to exacerbate, as can be seen in the mortality, morbidity and economic costs that these have generated in the last few decades. A discussion of climate-change risk in India included the comment that "vulnerability has typically contributed more to overall risk in Indian cities than hazard-exposure."[20] This is worth considering more generally in that so much of the human cost of extreme weather events in urban centres in low- and middle-income nations comes not from the "hazard" or the "disaster-event" but from the inadequacies in provisions to protect urban populations (or particular sections of the population) from it. For instance, in many urban centres, the lack of provision for drainage (and for maintaining existing drains) means that relatively minor rainstorms cause serious flooding. And even in cities that have adapted well to extreme weather, a storm or rainfall just a little more intense than the historic record often becomes a disaster.

In this paper, vulnerability to climate change is understood to mean the potential of people to be killed, injured or otherwise harmed by the direct or indirect impacts of climate change. This is most obvious in regard to risk from extreme events (such as storms or floods) but it includes risk from less direct impacts – for instance declining freshwater availability or livelihoods dependent on climate-sensitive resources.

Adaptation has to address pre-disaster and post-disaster vulnerabilities. For instance, it should focus on reducing the hazard where this is possible (e.g. better drainage that stops a heavy rainstorm creating floods) or reducing people's exposure to it (e.g. working with those who live in areas at risk of flooding to improve their housing or move to safer locations). It should also focus on reducing the impact of the hazard – for instance in responding rapidly to flooding, both to get the flood waters away from the settlements flooded and to respond to the flood's impacts on people's health, living conditions, assets and livelihoods. And finally, in the post-disaster response, to encourage and support measures that reduce risks to likely future hazards. But there are two difficulties in adapting to future risks. The first is that the scale and nature of the hazards it brings will be changing (and generally increasing). The second is the uncertainty in exactly what changes will happen and when. In the past, without climate change, for any location, it was much easier to establish the likely range and frequency of extreme weather events for which provisions had to be made.

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[19] Wilbanks, Romero Lankao et al. (2007), op. cit.

[20] Revi, Aromar (2007), *Climate Change Risk: A Mitigation And Adaptation Agenda For Indian Cities*, paper prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience, Taru, New Delhi, 23 pages. A slightly condensed version of this will be published in *Environment and Urbanization,* Vol. 20, No. 1 (2008).

Among the populations that are particularly vulnerable to climate-shocks are those living in particularly dangerous locations (for instance on floodplains), those living in settlements lacking protective infrastructure and those living in poor quality housing. Of course, within any vulnerable population, there are differentials in how much they are affected by the hazard (influenced by, for instance, age, health status and gender) and in coping capacities. Vulnerability is a product of exposure of people to such changes (which is influenced by the limits they face in being able to reduce this exposure) and limited or no capacity to cope (the immediate responses) and adapt (longer-term responses).

In all instances, people's capacity to avoid the hazard, to cope with it and to adapt (to reduce future risk) is influenced by individual/household resources (e.g. incomes, asset bases and knowledge) and community resources (e.g. for coping, the quality and inclusiveness of community organizations that provide or manage safety nets and other short- and longer-term responses). But in urban areas, it is also so much influenced by the extent and quality of infrastructure and public services, especially for vulnerable populations. The two factors that contribute to vulnerability – the risk of being killed, injured or otherwise harmed, and the coping and adaptation capacity – are largely determined by the development context[21] – since it is the development context that has such a strong influence on households' income, education and access to information, on people's exposure to environmental hazards in their homes and workplaces and on the quality and extent of provision for infrastructure and services (including post-event services).

Extreme weather events do not produce disasters without vulnerable populations. But it is difficult to assess the vulnerabilities of urban populations to these events (and to the impacts of climate change) because these vulnerabilities are so specific to each location and societal context. They cannot be reliably estimated from the larger-scale aggregate modelling of climate change.[22] They also cannot be reliably estimated without a detailed knowledge of local contexts. Yet it is still common to find generalizations made about the vulnerability of "developing countries" or their urban centres.

Of course, the increasing frequency and growing human and economic cost of disasters from (say) storms/floods in urban areas does not give us any precise information about the likely future cost of climate change. But disaster-loss data do provide a good starting point for estimating costs, and give an idea of the vulnerability of urban populations to certain physical events that are likely to become more common and/or more intense in many places. In addition, there has been an important change in how urban disasters are understood as they are seen as failures to understand vulnerabilities and act on them – and this too has relevance for understanding how to build cities' resilience to climate change.

Box 2: What are disasters?

Disasters are defined by events that result in large numbers of people killed or injured, or in large economic losses. The conventional view is that they are caused by exceptional or unusual events, including "natural" disasters. However, over the last 30 years, this has been questioned – as disasters come to be viewed not as unusual or natural events but as failures of development, as they occur because of little or no attention to reducing vulnerability. Storms, floods, droughts and heatwaves need not be disasters, if vulnerabilities to these have been much reduced.

The Centre for Research on the Epidemiology of Disasters (CRED), which holds the only publicly accessible global disaster database, defines disaster as "a situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance". To be entered into the EM-DAT database, at least one of the following criteria has to be fulfilled: 10 or more people reported killed; 100 people reported affected; a call for international assistance; and/or declaration of a state of emergency.[23] Other databases use different thresholds for inclusion, for example Swiss Reinsurance includes only those events with at least 20 deaths while DesInventar includes any reported event regardless of the scale of loss.[24]

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[21] Wilbanks, Romero Lankao et al. (2007), op. cit.
[22] Ibid.
[23] CRED EM-DAT; see http://www.em-dat.net/. See also International Federation of Red Cross and Red Crescent Societies (2002), *World Disasters Report: Focus on Reducing Risk*, Oxford University Press, Oxford and New York, 239 pages.
[24] Pelling M. (2005), "Disaster data: building a foundation for disaster risk reduction", International Federation of the Red Cross and Red Crescent Societies, *World Disasters Report 2005*, pages 173–180.

Disasters are usually classified by their triggering event as either natural or technological. Natural disasters include geophysical disasters such as volcanic eruptions and earthquakes, and hydro-meteorological disasters such as avalanches, landslides, droughts, famines, extreme temperatures, floods, fires and windstorms. Technological disasters include industrial and transport accidents.[25]

Many researchers working on disasters have pointed to the inadequacy of this simplistic categorization between "natural" and technological disasters. Allan Lavell points to the key distinction between natural hazards, socio-natural hazards (natural hazards that are socially induced), anthropogenic pollutant hazards and anthropogenic technological hazards – and the extent to which the scale and nature of most "natural disasters" have been much influenced by human activities.[26] As noted already, there is no disaster without a vulnerable population.

Cities by their very nature concentrate people and their homes, physical capital, industries and wastes. This can make them very dangerous places to live and work and make their populations very vulnerable to extreme weather events or other physical events that have the potential to be disasters. But this is best seen not as inherent to cities but as the product of inadequate planning and governance. Concentration produces risk through, for instance, the dangerous conjunction of residential and industrial land uses, the lack of space for evacuation and emergency vehicle access and potential for the spread of communicable disease. A high proportion of lower-income groups may settle on hazardous sites (for instance sites at risk from floods or landslides) but they do so because no other (safer) land is available to them – while also lacking access to the means to reduce their vulnerability.

Urban contexts generally increase risk of what Allan Lavell has termed "concatenated hazards" – as primary hazard leads to secondary hazard (e.g. floods creating water-supply contamination), as well as "natech" events where natural hazards trigger technological disasters. On the ground, the impacts of natural and technological hazards including pollution events overlap and compound one another – and this is one of the defining challenges of urban disaster-risk management.

But this same concentration of people and enterprises in urban areas also means economies of scale or proximity for many of the measures that reduce risks from extreme weather events – for instance in the per capita cost of measures to lessen the risks (e.g. better watershed management or drainage reducing the scale of floods), reduce the risks when the event occurs (e.g. buildings better able to withstand floods and early-warning systems to allow special measures to be taken) and respond rapidly and effectively when a disaster is imminent or happens. There is a greater capacity among a proportion of city dwellers to help pay for such measures, if they are made aware of the risks, and the measures are shown to be cost-effective. Most of the impacts of climate change do not add new risks but increase risk levels for hazards already evident without climate change – for instance, extreme weather events, floods, heatwaves or shortages of freshwater. Well-governed cities have already made provisions to reduce vulnerabilities to these. But most urban growth in low- and middle-income nations is happening without "good local governance" and so without the provisions needed to reduce risks – and often with processes that increase risks and numbers of people at risk.

Urban contexts pose particular challenges for governments

Most urban contexts are different from most rural contexts in regard to the spatial concentration of hazards and stressors (and the number of people at risk from them), the number of hazards (e.g. the range of infectious and parasitic diseases that can spread rapidly among concentrated populations, the close proximity of people, industries and industrial wastes) and their mix and potential for exacerbating each other (e.g. floods contaminating water supplies which lead to water-related disease epidemics). It is also common for cities to expand and develop in ways that erode natural defences or buffers (for instance wetlands) and increase flooding risks from rainfall (as an ever larger area is covered by buildings or paved surfaces).

Large sections of the urban poor are exposed to a range of environmental health hazards in their homes and workplaces plus a set of stressors (e.g. urban heat-island effect and human-induced water scarcity) –

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[25] Ibid.

[26] Lavell, Allan (1999), *Natural and Technological Disasters: Capacity Building and Human Resource Development for Disaster Management*, mimeo, 32 pages.

and climate change is likely to bring a range of new risks or heightened risk levels for already existing hazards and stressors – for instance in many cities through more frequent or severe storms, more extreme rainfall episodes, heat waves, constraints on freshwater supplies and, for coastal cities, sea-level rise.[27] There are also complex relationships between this mix of hazards and the many (inter-related) components of urban poverty which include not only the urban poor's inadequate incomes and limited asset bases but also very poor-quality housing, lack of basic infrastructure for providing water, sanitation, drainage and garbage removal and lack of civil and political rights. This greatly increases the vulnerability of the urban poor to most environmental hazards, including most of those related to climate change.

Environmental hazards and stressors are also obviously influenced by social, economic and political factors, as are people's capacity to cope with them and to adapt. Obviously, households facing falling real incomes or rising prices for necessities generally have less capacity to cope or to adapt in ways that reduce risk. Risk levels for large sections of the population are strongly related to governance limitations that not only fail to reduce the risks but often act to increase them – for instance governments that do nothing about the fact that lower-income groups can only find land for housing or housing in illegal settlements on floodplains to which government will not extend drainage and other infrastructure. These limitations in local government are, in turn, influenced by the tasks, responsibilities, powers, resources and structures they are permitted by higher levels of government. Thus, any analysis of hazards and vulnerabilities linked to climate change in any particular settlement needs to understand the complex 'bundle' of environmental, economic, social and political stressors that influence these.[28] Risks emerge from many sources – and can "cascade through interacting human and environmental systems to create adverse consequences."[29]

Certain urban characteristics have relevance for understanding risks from extreme weather events.[30]

- concentrated populations due to concentrated labour markets/income-earning opportunities for non-agricultural activities (which is what underpins virtually all urban centres);
- land markets unrelated to the land's agricultural potential, with land costs often pricing most or all low-income groups out of "official" land-for-housing markets – this means that large sections of the urban population acquire land and build housing outside the official system of land-use controls and building standards that is meant to reduce risks and stop settlements on land at risk from floods and storms;
- related to the above, large sections of the population living in housing constructed informally – with no attention to needed health and safety standards and no regulatory framework to protect tenants (it is common in cities for large sections of the low-income population to rent accommodation, often whole households living in one room or many adults sharing a single room);
- high-density populations plus concentrations of their solid and liquid wastes (a particular problem if no sewers/drains and waste-collection service remove these) – many provisions for disaster avoidance (e.g. thicker walls), response (access for emergency vehicles), or reducing disaster impacts (readily available open spaces not at risk from falling buildings) are not possible in crowded low-income settlements;
- large, impermeable surfaces and concentrations of buildings which disrupt natural drainage channels and accelerate runoff;
- patterns of urban form and buildings that do not take current and future hazards into account, which generate increased scales and levels of risk from floods, landslides, fires and industrial accidents;
- industrialization, inadequate planning and poor design generating secondary or "natech" risks;

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[27] de Sherbinin, Alex, Andrew Schiller and Alex Pulsipher (2007), "The vulnerability of global cities to climate hazards", *Environment and Urbanization*, Vol. 19, No. 1, pages 39-64; Rosenzweig, C. and W.C. Solecki (2001), "Climate change and a global city",, Environment, Vol. 43, No. 3, April, pages 8-18.

[28] see de Sherbinin, Schiller and Pulsipher 2007, op. cit.; also Romero Lankao (2007), op. cit.

[29] De Sherbinin, Schiller and Pulsipher 2007, op. cit. page 41.

[30] Based on list in Bull-Kamanga, Liseli, Kade Diagne, Allan Lavell et al. (2003), "Urban development and the accumulation of disaster risk and other life-threatening risks in Africa", *Environment and Urbanization,* Vol. 15, No. 1, pages 193–204.

- changes in the region around cities that cause or exacerbate risks (e.g. poor watershed management, often a particular problem for city governments as the watershed usually lies outside their jurisdiction);
- city governments and urban economies unable to cope with sudden movements of people into a city in response to crises elsewhere (linked to extreme weather events nearby, or to conflict).

Urban development is often a large creator of risk for much of the urban population – but with higher income groups and larger or more prosperous enterprises able to avoid most or all such risk. There are clearly very large differentials within most urban centres in people's exposure to risks from extreme weather events, and we need to understand the role of the state in this, and whether it acts to create or contribute to these differentials or to modify and reduce them. "Good local governance" is the main means by which such differentials to risks from extreme weather events (and many other environmental hazards) are reduced. This can occur through government demands made and enforced on private enterprises (e.g. concerning construction standards, occupational health and safety, pollution control, waste management, payment for infrastructure and services and disaster preparedness) and what it provides, supports and encourages for the population – especially those most at risk. *One of the most powerful measures of the quality of urban governance is the extent to which it reduces or removes the differentials in risk from serious injury, illness or premature death between high- and low-income groups in regard to both disasters and environmental hazards.*

Most urban research does not engage with disasters. If disasters are understood as unusual events (usually "natural" events) that require from the state a capacity to respond to them rapidly, these do not appear to be within the realm of conventional urban research. If disasters are understood to be caused by urban development (or the scale of their impacts and their frequency increased by urban development) and, as Lavell suggests, socially constructed with their impacts conditioned by existing social and spatial segregation, it is more difficult for urban research to ignore them.[31] Indeed, any urban researcher with an interest in poverty and vulnerability needs to integrate an understanding of the current or potential impact of extreme weather events into their work.

The changes in understanding of what causes disasters noted above, with disasters recognized as failures of development, has changed the understanding of how to avoid them or greatly reduce their impact[32] – and this change in thinking has great relevance to reducing the vulnerability of city populations to climate change. This means a shift from focusing on hazard-prone areas and the increasing magnitude of losses (and on engineering and structural solutions) to understanding (and changing) the complex urban processes that increase risks – for instance the range of "risk-accumulation" processes that are increasing the vulnerability of large sections of their population to floods or landslides. This also means a shift in who is seen as responsible for addressing disasters. For instance, the armed forces may be given central responsibilities for responses to disasters – but they can do little or nothing to reduce risk from disasters in urban areas. There is recognition of the need to integrate disaster-risk reduction into all line departments of government and to support community–government partnerships in identifying and acting to reduce risks. As Sections IV and V below make clear, these two issues are also at the core of reducing vulnerability to climate change. But, as yet, only rarely has this change in understanding of what causes disasters meant a change in policies on disaster management. Local, national and international agencies with responsibilities for conventional disaster management lack the skills and capacities to make such a change – and often the motivation to change, especially if their budget depends on disasters to respond to. Addressing the developmental failures that underpin urban disasters is more difficult, especially for international agencies, and comes up against powerful vested interests. Meanwhile, few powerful urban actors benefit from risk-reduction initiatives for those living in informal settlements.

The continuum of risk from everyday to catastrophic disasters

A good adaptation agenda for any urban area needs to understand all the environmental risks to which its

[31] Lavell, Allan (2001), Environmental Degradation, Risk and Urban Disasters: Issues and Concepts – Towards the Definition of a Research Agenda, mimeo.

[32] See for instance the work of La Red in Latin America and the work of Peri-peri and AURAN in Africa described in Bull-Kamanga et al. 2003, op. cit. See also work of Allan Lavell, Ben Wisner, Terry Cannon, Mark Pelling; Pelling, Mark (2003), *The Vulnerability of Cities: Natural Disasters and Social Resilience*, Earthscan, London, 212 pages.

population (or subsets) are exposed, and their interconnections. When serious illness, injury or premature death, disruption to livelihoods and loss of property occurs, this is always a "disaster" for some persons. But an event will be officially classified as a disaster only if it meets certain criteria – for instance ten or more people killed or 100 or more seriously affected (see Box 2). Disaster managers generally focus only on events officially classified as disasters, so non-disaster events (and small disasters e.g. with less than ten persons killed) are not considered. This means that such managers may not see the links between non-disaster events and disasters, and the risk-accumulation processes common in urban areas that usually increase disaster and non-disaster risks. Meanwhile, urban-development policy makers often focus on non-disaster risks (which in most urban areas in low- and middle-income nations contribute far more to health burdens and to poverty than disasters) but this means that they miss the potential links between risk reduction for everyday hazards and small and large disasters.

Table 3: Comparing disasters, "small disasters" and everyday risk

Nature of event	Disasters	Small disasters	Everyday risks
Frequency	Generally infrequent	Frequent (often seasonal)	Every day
Scale	Large or potential to be large: 10+ killed, 100+ seriously injured	3–9 persons killed, 10+ injured	1–2 persons killed, 1–9 injured
Impact on all premature death and serious injury/illness	Can be catastrophic for specific places & times but low overall	Probably significant and under-estimated contribution	Main cause of premature death and serious injury
	VERY LARGE IMPACT	CONTINUUM OF RISK	SMALL IMPACT
	LOW	FREQUENCY	VERY HIGH

SOURCE: Bull-Kamanga, Liseli, Kade Diagne, Allan Lavell, Fred Lerise, Helen MacGregor, Andrew Maskrey, Manoris Meshack, Mark Pelling, Hannah Reid, David Satterthwaite, Jacob Songsore, Ken Westgate and Andre Yitambe (2003), "Urban development and the accumulation of disaster risk and other life-threatening risks in Africa", *Environment and Urbanization,* Vol 15, No 1, pages 193–204.

One way to get some idea of the likely costs of climate-change-related disasters would be an analysis of the impact on urban populations of disasters caused by triggers whose intensity or frequency climate change is likely to increase. Unfortunately, the records on the impacts of disasters on urban populations are very inadequate. Only data by EM-DAT and Munich Reinsurance and Swiss Reinsurance have global coverage. EM-DAT data are not disaggregated to urban areas (and held only at the national scale) while the Munich Re and Swiss Re datasets do have some spatially fixed data but their focus is more on insured and economic losses than on human loss. Geo-referenced data are available from a growing collection of national-level databases following what is known as the DesInventar methodology (including 16 countries in Latin America and the Caribbean, and states in the US, India and some neighbourhoods in Cape Town).

All of these datasets are undermined by the lack of an internationally agreed definition of a disaster event (or range of events at different levels of impact) and of systematic data-collection mechanisms. For these datasets, data are drawn from the news media, NGO reports and declarations of emergency. This means that "small disasters" are often not recorded, as these are not necessarily reported in the media. The DesInventar methodology seeks to include "small disasters" that EM-Dat does not record and its application shows very large discrepancies between official lists of "disasters" and the actual number of disasters. For instance, in Colombia, 87 disasters were recorded by EM-DAT but there were 2,200 more disasters not registered but which met official criteria for what constitutes a disaster, and 13,000 other smaller disasters.[33] A database in Cape Town that sought to record all events registered over 12,500 incidents which contrasts with the 600 identified large events and declared disasters.[34] Almost half of these occurred in informal settlements. An analysis of disaster events in Mexico, 1970 to 2001, sought to document all events with at least one mortality and found that floods were the most common disaster,

[33] Marulanda, Mabel C., Omar D. Cardona and Alex H. Barbat (no date), *Revealing the Impact of Small Disasters to Economic And Social Development*, United Nations University, Institute for Environment and Human Security, UNU, Tokyo, 21 pages, http://www.ehs.unu.edu/file.php?id=295

[34] Bull-Kamanga et al. (2003), op. cit.

and a quarter of all deaths from flooding came from events with fewer than four deaths – i.e. much too small to be included in international disaster datasets.[35]

Extreme weather events and risk-accumulation processes

The above studies in particular cities show the very large scale of injury, death and loss of property caused by extreme weather events or accidental fires that went unregistered as disasters or were excluded by the criteria used to define a "disaster". Such detailed local studies are needed in all urban centres, not only to show the health and other costs from extreme weather events (including "small" disasters whose aggregate impact may be larger than events classified as "disasters") but also because:

- the number, territorial spread and impact of disasters or small disasters may be increasing rapidly;
- risk from these may graduate in time to larger events as populations and their vulnerabilities increase in the areas close to the hazard sources and as hazards grow in size and potential intensity;
- developing an ability to intervene to prevent "small" disasters or limit their damaging impacts can also serve to develop a capacity for doing so for larger events.[36]

Small disasters from extreme weather events that are recurrent – for instance floods that happen every time there is heavy rainfall – can also undermine any community's resilience and its capacity to make the investments and adjustments needed to protect against larger disasters. This may lead to a general acceptance of risk or a failure to critique the association of poverty and risk. The need for every urban centre to have strong, locally generated data on risks and local analyses of risk and risk accumulation processes is fundamental to facilitating adaptation – and will be discussed in more detail in Section V below.

III. UNDERSTANDING VULNERABILITIES OF CITIES AND THE URBAN POOR TO CLIMATE VARIABILITY AND CHANGE

The vulnerability of cities to climate change

The Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) of 2007 noted the following, all with high confidence:

"The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring.

"Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies.

"Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, and these increases will be substantial in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages." [37]

Table 4, drawn from the IPCC's Fourth Assessment, lists the different aspects of climate change, the evidence for current impact, projected future impacts and the zones or groups most affected. It highlights the different kinds of impacts that arise from changes in extremes and changes in means; it also notes the

[35] Data source is DesInventar http://www.desinventar.org/desinventar.html
[36] Lavell (1999), op. cit.
[37] Adger, Neil, Pramod Aggarwal, Shardul Agrawala et al. (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability: Summary for Policy Makers*, Working Group II Contribution to the Intergovernmental Panel on Climate Change; Fourth Assessment Report, IPCC Secretariat, WHO AND UNEP, Geneva, page 7.

need to consider the impacts of abrupt climate change, while also noting that its significance is less clearly established.

Table 4: Selected examples of current and projected impacts of climate change on industry, settlement and society and their interaction with other processes

Climate-driven phenomena	Evidence for current impact/ vulnerability	Other processes/ stresses	Projected future impact/ vulnerability	Zones, groups affected
a) Changes in extremes				
Tropical cyclones, storm surge	Flood and wind casualties & damages; economic loses; transport, tourism, infrastructure (e.g. energy, transport), insurance	*Land use/ population density in flood-prone areas; flood defences; institutional capacities*	*Increased vulnerability in storm-prone coastal areas; possible effects on settlements, health, tourism, economic and transportation systems, buildings & infrastructures*	*Coastal areas, settlements, and activities; regions and populations with limited capacities and resources; fixed infrastructures; insurance sector*
Extreme rainfall, riverine floods	Erosion/landslides; land flooding; settlements; transportation systems; infrastructure	*Similar to coastal storms plus drainage Infrastructure*	*Similar to coastal storms plus drainage infrastructure*	*Similar to coastal storms*
Heat- or cold-waves	Effects on human health; social stability; requirements for energy, water and other services (e.g. water or food storage), infrastructures (e.g. energy transport)	Building design and internal temperature control; social contexts; institutional capacities	Increased vulnerabilities in some regions and populations; health effects; changes in energy requirements	*Mid-latitude areas; elderly, very young, and/or very poor populations*
Drought	Water availability, livelihoods, energy generation, migration, transportation in water bodies	*Water systems; competing water uses; energy demand; water-demand constraints*	Water-resource challenges in affected areas; shifts in locations of population & economic activities; additional investments in water supply	*Semi-arid and arid regions; poor areas and populations; areas with human-induced water scarcity*
b) Changes in means				
Temperature	Energy demands and costs; urban air quality; thawing of permafrost soils; tourism and recreation; retail consumption; livelihoods; loss of meltwater	Demographic and economic changes; land-use changes; technological innovations; air pollution; institutional capacities	Shifts in energy demand; worsening of air quality; impacts on settlements and livelihoods depending on melt water; threats to Settlements / infrastructure from thawing permafrost soils in some regions	Very diverse, but greater vulnerabilities in places and populations with more limited capacities and resources for adaptation
Precipitation	Agricultural livelihoods, saline intrusion, tourism; water infrastructures, tourism, energy supplies	*Competition from other regions/ sectors; water-resource allocation*	*Depending on the region, vulnerabilities in some areas to effects of precipitation increases (e.g. flooding, but could be positive) and in some areas to decreases (see drought above)*	Poor regions and populations
Saline intrusion	Effects on water infrastructures	Trends in groundwater withdrawal	Increased vulnerabilities in coastal areas	Low-lying coastal areas, especially those with limited capacities and resources
Sea-level rise	Coastal land uses: flood risk, water logging; water infrastructures	*Trends in coastal development, settlement and land uses*	*Long-term increases in vulnerabilities of low-lying coastal areas*	*Same as above*

c) Abrupt climate change	Analyses of potentials	Demographic, economic, and technological changes; institutional developments	Possible significant effects on most places and populations in the world, at least for a limited time	Most zones and groups

Dark shading with text in italics indicates very significant in some areas and/or sectors; light shading indicates significant; no shading indicates that significance is less clearly established.

SOURCE: Wilbanks, Tom and Patricia Romero Lankao with Manzhu Bao, Frans Berkhout, Sandy Cairncross, Jean-Paul Ceron, Manmohan Kapshe, Robert Muir-Wood and Ricardo Zapata-Marti (2007), "Chapter 7: Industry, Settlement and Society", in Parry, Martin, Osvaldo Canziani, Jean Palutikof, Paul van der Linden and Clair Hanson (editors) *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, pages 357-390.

For cities, perhaps the most obvious increased risk comes from the likely increase in the number and intensity of extreme weather events such as heavy rainstorms, cyclones or hurricanes. The cities most at risk are those where these events are already common – although there is some evidence of the geographic range of some extreme weather events expanding. Coastal cities will be doubly at risk as sea-level rise increases hazards from coastal flooding and erosion. For any city, the scale of the risk from these extreme weather events is also much influenced by the quality of housing and infrastructure in that city and the level of preparedness among the city's population and key emergency services. For small and large coastal settlements the integrity of coastal ecosystems and in particular protective mangrove and saltmarsh systems will also influence risk. City dwellers in high-income nations have had risks in relation to injuries and deaths much reduced by decades of investment in housing and infrastructure – and economic/financial losses much reduced by insurance. But the devastation of New Orleans by Hurricane Katrina in 2005 is an example of how there are still exceptions – both in the lack of investment in flood defences coupled with degradation of the coastal environment, and in the inadequate institutional capacity of emergency services. It also illustrates the higher vulnerabilities of lower-income groups.

In high-income nations, buildings and infrastructure are often built to withstand extreme weather events of an intensity judged to be very unlikely (i.e. once in a thousand years), but these can still be overwhelmed by the increased intensity of storms or of associated rainfall. In many cities, there is evidence of what used to be a "once in a hundred years" event becoming more common than this. In addition, cities are also vulnerable to any damage to the larger systems on which they depend – for instance for water supply and treatment, transport and electricity (and thus everything that depends on electricity, including lighting, pumping and communications).[38]

Flooding

Urban areas always present some risk of flooding when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil – and so produce more runoff. Heavy and/or prolonged rainfall produces very large volumes of surface water in any city, which can easily overwhelm drainage systems. In well-governed cities, this is rarely a problem because good provision for storm and surface drainage is easily built into the urban fabric, with complementary measures to protect against flooding – for instance the use of parks and other areas of open space to accommodate floodwaters safely from unusually serious storms. But in poorly governed cities, this does not happen – and it is common for buildings or infrastructure to be constructed that actually obstruct natural drainage channels. For instance, in Dhaka, buildings often encroach on or fill in drains and many natural drains have been filled up to construct roads.[39] Mombasa faces comparable problems.[40] In cities or

[38] Wilbanks, Romero Lankao et al. (2007), op. cit; Kreimer, A., M. Arnold and A. Carlin (editors) (2003), *Building Safer Cities: The Future of Disaster Risk*, World Bank, Washington DC.

[39] Alam, Mozaharul and M.D. Golam Rabbani (2007), "Vulnerabilities and responses to climate change for Dhaka", *Environment and Urbanization*, Vol. 19, No. 1, pages 81–97.

neighbourhoods with inadequate solid-waste management or drain maintenance, garbage and plant growth can quickly clog drains, leading to localized flooding with even light rainfall. For instance, in Georgetown, Guyana this led to 29 local floods between 1990 and 1996.[41]

Box 3: Examples of cities at risk from floods and/or sea-level rise

ALEXANDRIA (Egypt): An assessment of the vulnerability of the most important economic and historic centres along the Mediterranean coast (the cities of Alexandria, Rosetta and Port-Said) suggests that, for a sea-level rise of 50cm, over 2 million people will have to abandon their homes, 214,000 jobs would be lost and the cost in terms of land and property value and tourism income lost would be over $35 billion. Alexandria alone has more than 3 million inhabitants. But it is not really possible to put a monetary value on the loss of the world-famous historic, cultural and archaeological sites.[42]

COTONOU (Benin): Cotonou is Benin's largest urban centre, its main port and a key part of the national economy; it has around 700,000 inhabitants. Large sections of the city economy and of its residential neighbourhoods are particularly vulnerable to sea-level rise and storm surges. The continued advance of the sea, coastal erosion and the rise in sea level, exacerbated by human activity on the coast, have medium- and long-term consequences that are already threatening vulnerable communities and disrupting the least-protected sensitive ecosystems. Some roads, beaches and buildings have already been destroyed by the coastline's regression in the last ten years.[43] In addition, provision for drainage is inadequate; the city has no sewer system and only a small proportion of solid wastes are collected; in addition, most of the population lives in informal settlements.[44]

DHAKA (Bangladesh): Dhaka, the capital of Bangladesh, has over 10 million inhabitants and is central to Bangladesh's economy (and its economic success in recent years). Its population has grown more than 20-fold in the last fifty years. This is a city already very vulnerable to flooding, especially during the monsoon season – as shown by the major floods in 1954, 1955, 1970, 1980, 1987, 1988, 1998 and 2004; the 1988, 1998 and 2004 floods were particularly severe, with very large economic losses. These were mainly caused by the spill-over from surrounding rivers. Large sections of the city are only a few metres above sea level. Much of Bangladesh outside Dhaka is also very vulnerable to floods – and the combination of sea-level rise and increased frequency and intensity of storms that climate change is likely to bring greatly increases these risks.[45]

LAGOS (Nigeria): With a total population of around 10 million inhabitants,[46] Lagos has very inadequate provision for basic infrastructure to cope with flooding. "Normal" rainfall brings flooding to many areas of the city, largely as a result of the inadequacies in provision for sewers, drains and wastewater management. Any increase in the intensity of storms and storm-surges is likely to increase such problems; much of the land in and around Lagos is less than 2 metres above sea level. The site on which Lagos is built is not well suited to a city this size; when the colonial government moved the capital here, no one would have anticipated the city growing to such a size. However, the lack of good local governance is far more important as a cause of so many people and enterprises being at risk of flooding. In many areas, roads have been built without complementary gutters for rainwater. Where a drainage system exists, it is often not properly constructed and maintained. The lack of solid-waste collection compounds the problem as wastes block gutters and drains. In addition, many buildings have been erected in ways that block storm-water routes. Little attention is given to clearing the drains, in advance of periods of the year when rain is expected. Many low-income settlements are built in areas at high risk of flooding (many on stilts), largely because safer sites are too expensive.[47]

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[40] Awuor, Cynthia B., Victor A. Orindi and Andrew Adwerah (2007), Climate Change and Coastal Cities: The Case of Mombasa, Kenya, case study prepared for the Rockefeller Foundation.

[41] Pelling M. (1997) "What determines vulnerability to floods: a case study in Georgetown, Guyana", *Environment and Urbanization*, Vol. 9, No. 1, pages 203–226.

[42] El-Raey, M. (1997), "Vulnerability assessment of the coastal zone of the Nile Delta of Egypt to the impact of sea level rise", *Ocean and Coastal Management*, Vol. 37, No. 1, pages 29–40.

[43] Dossou, Krystel and Bernadette Glehouenou-Dossou (2007), "The vulnerability to climate change of Cotonou (Benin): the rise in sea level", *Environment and Urbanization*, Vol. 19, No. 1, pages 65–79.

[44] Dedehouanou, Houinsou (1998), "Coping with house waste management in Cotonou", *Environment and Urbanization*, Vol. 10, No. 2, October, pages 191–208.

[45] Alam and Golam Rabbani (2007), op. cit.

[46] Many sources suggest that Lagos has a much larger population than this – but these may overstate its population. The preliminary census data for 2006 suggest that Lagos State in which the city is located had 9 million inhabitants. The 1991 census suggested that Lagos urban agglomeration had around 5 million inhabitants. The movement of the federal capital to Abuja will also have taken away one of the key drivers of Lagos's growth.

[47] http://allafrica.com/stories/200704020193.html; Aina, Tade Akin (1995), "Metropolitan Lagos: population growth and spatial expansion; city study", background paper for the Global Report on Human Settlements, 31 pages; Aina, Tade Akin, Florence Ebam Etta and Cyril I. Obi (1994), "The search for sustainable urban development in metropolitan Lagos, Nigeria", *Third World Planning Review,* Vol. 14, No. 2, pages 1–18; Iwugo, Kenneth O., Brian

BANJUL (Gambia): Banjul has more than half a million inhabitants. Most of the city is less than 1 metre above sea level and flooding is common after heavy rain in the city, in settlements established on reclaimed land in dried-up valleys, and in settlements close to mangrove swamps and wetlands. Problems with flooding are likely to increase under a warmer climate with an increase in the strength and frequency of tropical storms. In the coastal zones of the Gambia, a sea-level rise of 1 metre is likely to inundate 92 square kilometres. Shoreline retreat would vary from around 100 metres in the harder cliffed zone to 839 metres in the gently sloping, sandy plain near Sanyang Point.[48]

ABIDJAN (Cote D'Ivoire). Abidjan's population in the 1998 census was 2.8 million. A sea-level rise of 1 metre is likely to inundate 562 square kilometres along the coastline of the Abidjan region; lowland marshes and lagoons dominate the coastal zone. Average retreat will vary from 36 to 62 metres. Although some important areas of Abidjan lie on a plateau and may escape the direct effects of sea-level rise, major economic centres including the nation's largest port and much of the international airport are on land less than 1 metre above sea level.[49] Around half a million inhabitants live in precarious housing in informal settlements; a high proportion of these are tenants.[50]

PORT HARCOURT (Nigeria): An extreme 10-hour rainfall in July 2006 drove 10,000 residents out of their homes and caused widespread traffic chaos. The Niger delta frequently experiences flood problems that are aggravated by structures such as the Port Harcourt–Patani–Warri highway that cuts across natural drainage lines and acts as a barrier to floodwaters.[51] Blockage of channels by debris and obstruction of floodways by new construction were seen as the main obstacles contributing to Port Harcourt's flooding. The city has more than a million inhabitants.

MOMBASA (Kenya): Mombasa is Kenya's second-largest city (with over 700,000 inhabitants) and the largest seaport in East Africa serving many counties other than Kenya. An estimated 17 per cent of Mombasa's area (4,600 hectares) could be submerged by sea-level rise of 0.3 metres,[52] with a larger area rendered uninhabitable or unusable for agriculture because of waterlogging and salt stress. Sandy beaches, historic and cultural monuments and several hotels, industries and port facilities also negatively affected. Mombasa already has a history of disasters related to climate extremes, including floods that cause serious damage and often loss of life nearly every year.[53]

BUENOS AIRES (Argentina): The urban agglomeration of 14 million inhabitants with Buenos Aires at its centre is located on the banks of the Rio de la Plata. Floods are common; there were 35 floods in the metropolitan area from 1985 to 2003. With its close proximity to the Rio de la Plata, the urban area is highly vulnerable to sea-level rise and storm surges – and from flooding from intense rainfall – because of the inadequacies in provision for storm and surface drainage.[54] In 100 years, the Rio de la Plata is expected to have average water levels of 60–100cm higher than today, and stronger winds and storm surges. Within the metropolitan area, the zones most at risk are the low-lying lands of the lower basins of the rivers Reconquista and Matanza-Riachuelo, and these have high concentrations of informal settlements.

BAMENDA (Cameroon): Bamenda's population expanded more than ten-fold between 1965 and 1993, to reach around 270,000 in 1993. Human settlements have expanded up hill-slopes and onto wetlands because land is very cheap there (land can be 300–400 times more expensive within the urban district compared to the very steep slopes and wetlands) but it is difficult (and expensive) to build stable, safe homes there. Around 20 per cent of Bamenda's population lives on floodplains and around 7 per cent lives in informal settlements on steep slopes. There are great

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D'Arcy and Robert Andoh (2003), "Aspects of land-based pollution of an African coastal megacity of Lagos", paper presented at Diffuse Pollution Conference, Dublin, pages 14-122 to 14-124; Adeyinka Sunday, Okude and Taiwo Olalekan John (2006), "Lagos shoreline change pattern: 1986–2002", *American-Eurasian Journal of Scientific Research*, Vol. 1, No. 1, pages 25–30; Nwafor, J.C. (1986), "Physical environment, decision-making and land use development in Metropolitan Lagos", *GeoJournal*, Vol. 12, No. 4, pages 433–442.

[48] Jallow, Bubu P., Sekou Toure, Malang M.K. Barrow and Assa Achy Mathieu (1999), "Coastal zone of The Gambia and the Abidjan region in Cote D'Ivoire: sea level rise vulnerability, response strategies and adaptation options", *Climate Research*, Vol. 12, pages 129–136.

[49] Jallow et al. (1999), op. cit; Attahi, Koffi (1992), "Planning and management in large cities: a case study of Abidjan, Cote D'Ivoire", in UNCHS (Habitat), *Metropolitan Planning and Management in the Developing World: Abidjan and Quito*, Nairobi, pages 31–82; Semboloni, Ferdinando (1999), "Planning the evolution of a city. A case study of Abidjan", *Third World Planning Review*, Vol. 21, No. 2, pages 201–355; Dubresson, Alain (1997), "Abidjan: from the public making of a modern city to urban management of a metropolis" in Rakodi, Carole (editor), *The Urban Challenge in Africa; Growth and Management of its Large Cities*, United Nations University Press, Tokyo, pages 252–291; Appessika, Kouamé (no date), The case of Abidjan, Ivory Coast, case study for the Global Report, 2003, UN Habitat, Nairobi.

[50] Yapi-Diahou, Alphonse (1995), "The informal housing sector of the metropolis of Abidjan, Ivory Coast", *Environment and Urbanization*, Vol. 7, No. 2, October, pages 11–29.

[51] Abam, T.K.S., C.O. Ofoegbu, C.C. Osadebe and A.E. Gobo (2000), "Impact of hydrology on the Port-Harcourt-Patani-Warri Road ", *Environmental Geology*, Vol. 40, Nos 1 and 2, pages 153-162.

[52] Mahongo, S. (2006), "Impacts of Sea Level Change", presented at the ODINAFRICA/GLOSS Training Workshop on Sea-Level Measurement and Interpretation, Oostende, Belgium, 13–24 November, quoted in Awuor et al. (2007), op. cit.

[53] Awuor et al. (2007), op. cit.

[54] Hardoy, Jorgelina and Gustavo Pandiella (2007), Background paper on climate change and cities in Argentina, prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience.

inadequacies in provision for water, sanitation, schools, health posts, roads and drainage. Land clearance for settlement and for quarrying and sand-mining, along with other land-use changes caused by urban expansion, have created serious problems of soil erosion – with the soil that is washed down the hills blocking drainage channels and changing peak water flows. These have exacerbated problems with floods, although flooding has long been a problem in Bamenda. It is difficult to address these problems, especially given the economic crisis and the absence of capacity and skills within the local authority.[55]

Climate change has the potential to increase flooding risks in cities in three ways: from the sea (higher sea levels and storm surges); from rainfall – for instance by heavier rainfall or rainfall that is more prolonged than in the past; and from changes that increase river flows – for instance through increased glacial melt. The IPCC Working Group II noted that heavy precipitation events are very likely to increase in frequency and will augment flood risk and the growing evidence of increased runoff and earlier spring-peak discharges in many glacier- and snow-fed rivers.[56] For some cities and regions, climate change is likely to reduce annual average rainfall – but greater extremes in individual rainfall events mean that overall flood hazard may not be reduced.

For all cities, flood hazard in the near future will be influenced as much – if not more – by land-use practices in surrounding watersheds (flooding in adjacent watersheds can disrupt communications and force people to migrate to the city), and by solid-waste management, land-use and drain maintenance in the city. This means that, for many cities, future risk can be reduced in the face of climate change by appropriate management and governance. However, without urgent and significant investment, climate change will add additional flood hazard onto drainage systems that are unable to cope with current rainfall.

A study by ActionAid, *Unjust Waters*, documents the lack of provision in six African cities for reducing flood risks or for managing floods when they happen.[57] Floods are already having very large impacts on cities and smaller urban centres in many African nations – for instance the floods in Mozambique in 2000 which included heavy floods in Maputo, the floods in Algiers in 2001 (with around 900 people killed, and 45,000 affected); heavy rains in East Africa in 2002 that brought floods and mudslides forcing tens of thousands to leave their homes in Rwanda, Kenya, Burundi, Tanzania and Uganda, and the very serious floods in Port Harcourt and in Addis Ababa in 2006. Discussions with residents in informal settlements in various cities found that flooding is more frequent and intense and often occurring in locations previously not at risk. They also showed how little local government was doing to address these issues.

Box 4: Flooding in African cities

Flooding is becoming an increasingly severe and more frequent problem in cities in Africa, with the impacts particularly felt by the urban poor. Climate change is aggravating flooding problems by altering rainfall patterns, tending to increase storm frequency and intensity and thus the potential for flooding. But, in most cities, local changes are greatly increasing flood risk by restricting where floodwaters can go, as large parts of the ground are covered with roofs, roads and pavements and natural channels are obstructed – and also as more drains are built, ensuring that water moves to rivers more rapidly. These mean increased local runoff and higher flood frequency, magnitude and duration. Flooding is aggravated by the occupation of floodplains, usually by informal settlements, and the lack of attention to household waste collection and the construction and maintenance of drainage channels. Now, even quite modest storms produce high flows in rivers or drains, and floods.

Four different types of flooding are evident: localized flooding due to inadequate drainage; flooding from small streams whose catchment areas lie almost entirely within the built-up area; flooding from major rivers on whose banks urban areas are built; and coastal flooding from the sea or through a combination of high tides and high river flows from inland. Localized flooding occurs many times a year in many informal settlements, because there are few drains (or those that exist are blocked), most of the ground is highly compacted and pathways between dwellings become streams after heavy rain.

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[55] Acho-Chi (1998), "Human interference and environmental instability: addressing the environmental consequences of rapid urban growth in Bamenda, Cameroon", *Environment and Urbanization*, Vol. 10, No. 2, pages 161–174.
[56] Adger, Aggarwal, Agrawala et al. (2007), op, cit.
[57] A summary of this report will be published in the April 2008 issue of *Environment and Urbanization*; the full report can be obtained from ActionAid (including being downloadable from www.actionaid.org).

SOURCE: Douglas, Ian, Kurshid Alam, MaryAnne Maghenda, Yasmin Mcdonnell, Louise McLean and Jack Campbell (2008), "Unjust waters: climate change, flooding and the urban poor in Africa", *Environment and Urbanization*, Vol. 20, No 1. This is drawn from a longer report: *Climate change, urban flooding and the rights of the urban poor in Africa: Key findings from six African cities*, ActionAid International, London. Available at: http://www.actionaid.org.uk/doc_lib/urban_flooding_africa_report.pdf

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In Asia, the very serious floods that have affected Dhaka are noted in Box 3 above. Mumbai had very serious floods in 2005 which left over 1,000 people dead and caused massive damage to homes, livelihoods and asset bases. Jakarta (and other areas in Indonesia) suffered very serious floods in February 2007. Yet for every flood large enough to get noticed internationally, there are hundreds that do not get reported but kill and seriously injure many people and destroy or damage many people's homes and assets.[58]

In Latin America, floods are the most frequent weather disaster and they often overwhelm the physical infrastructure, human resilience and social organization of cities.[59] Events such as the December 1999 flash floods and landslides in Caracas killing nearly 30,000, or the floods resulting from Hurricanes Stan in 2005 (more than 1,500 deaths) and Mitch in 1998 (around 18,000 deaths) show that the poor in these countries are the most likely to be killed or harmed by extreme weather-related events.

In addition to flood hazard, higher average and more extreme rainfall events associated with climate change will also generate increased hazard from landslides and mudflows, and in alpine areas from avalanche. Such events are usually localized and (like floods) are a primary trigger for local disasters. Consequently, however, the impact of these events (and of local flooding) on cities can be greatly under-estimated.

Box 5: River and inland flooding and extreme rainfall events in India

After drought, the most important climate-change risk in India is increased riverine and inland flooding, especially in northern and eastern India (and adjoining Nepal and Bangladesh). In eastern India, tens of millions of people are currently affected by flooding for three to six months of the year.[60] Increased precipitation and higher peak monsoon river flows due to glacial regression could exacerbate the situation for tens of millions more. This is largely due to the high population densities across this region, combined with very high vulnerability to flooding, due to a mix of poorly designed and executed flood-management systems, complex land and water tenure regimes and high levels of poverty, which over the last few decades has severely degraded the coping capacity of millions of people.[61]

Climate change is expected to increase the severity of flooding in many Indian river basins, especially in the Godavari and Mahanadi basins, along the eastern coast.[62] Floods are also expected to increase in north-western India adjoining Pakistan, and in most coastal plains in spite of upstream dams. Extreme precipitation is expected to increase substantially over a large area over the west coast and in central India.[63] Gujarat, one of India's most prosperous states, has experienced severe flooding for three consecutive years starting in 2004, causing large economic losses in its cities due to extreme precipitation in upstream catchments.[64] The devastating Mumbai floods of 2005 were caused by an extreme weather event. The bulk of the city services were shut down for almost five days with no contact via rail, road or air with the rest of the country. Over 1,000 people lost their lives and the city's

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[58] Nchito, Wilma S. (2007), "Flood risk in unplanned settlements within Lusaka", *Environment and Urbanization*, Vol. 19, No. 2, pages 539-551.
[59] Confalonieri, U. Menne, B. Akhtar R., Ebi, K., Hauengue, M., Kovats, R.S. Revich, B. and Woodward, A. (2007), Chapter 8: *Human Health*, in Parry, Canziani, Palutikof, van der Linden and Hanson (editors), op. cit. pages 391-431.
[60] Mishra, D.K. (1999), "Flood protection that never was: Case of Mahananda Basin of North Bihar*", Economic and Political Weekly* XXXIV(29), July.
[61] De Vries, H.J.M., A. Revi, G.K. Bhat, H. Hilderink and P. Lucas (2007), *India 2050: Scenarios for an Uncertain Future*, Netherlands Environment Assessment Agency (MNP), Bilthoven.
[62] Gosain, A.K., Sandhya Rao and Debajit Basuray (2006), "Climate change impact assessment on hydrology of Indian river basins", IIT and INRM Consultants Pvt Ltd, New Delhi, *Current Science*, Vol. 90, No. 3, 10 February, pages 346–353.
[63] Rupa Kumar, P., A.K. Sahai, Krishna Kumar, et al. (2006), "High-resolution climate change scenarios for India for the 21st century", Indian Institute of Tropical Meteorology, Pune, *Current Science*, Vol. 90, No. 3, 10 February, pages 334–345.
[64] GSDMA/TARU (2005), *Gujarat Vulnerability and Risk Atlas*, TARU, Gandhinagar.

economy effectively ceased – due to a combination of institutional failures, poor preparedness and the extreme vulnerability of the poor.[65]

SOURCE: Revi, Aromar (2007), *Climate Change Risk: A Mitigation and Adaptation Agenda for Indian Cities*, paper prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience, Taru, New Delhi, 23 pages. A slightly condensed version of this will be published in *Environment and Urbanization* Vol. 20, No 1, 2008

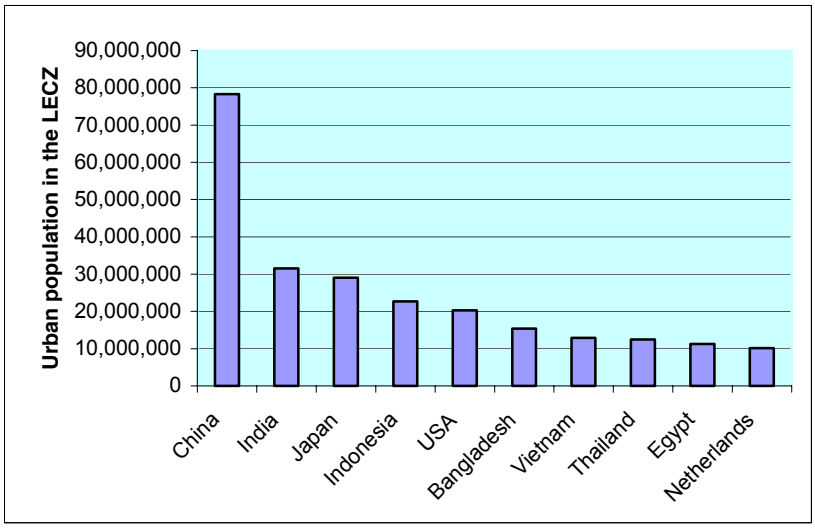
Storms, sea-level rise and coastal urban populations

The IPCC states: *"coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas[66] (very high confidence).*

"Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable"[67] (very high confidence).

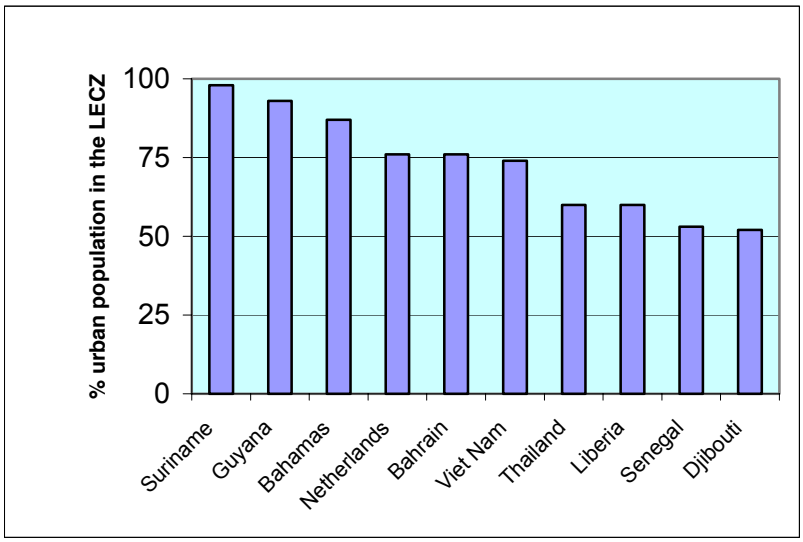
It is difficult to estimate with any precision how many people are at risk from the increased frequency and intensity of extreme-weather events and the sea-level rise that climate change will bring. The first detailed analysis on the number and proportion of urban dwellers (and total populations) living in the low-elevation coastal zone was published recently.[68] This zone – the continuous area along the coast that is less than 10 metres above sea level – represents 2 per cent of the world's land area but contains 10 per cent of its total population (i.e. over 600 million people) and 13 per cent of its urban population (around 360 million people). Almost two-thirds of the world's cities with more than 5 million inhabitants fall in this zone, at least partly. Low-income and lower-middle-income nations have a higher proportion of their urban population in this zone than high-income nations. The least developed nations, on average, have nearly twice the proportion of their urban population in this zone, compared to high-income nations. Figures 1 and 2 give the ten nations with the largest urban populations and the largest proportion of their urban population in this zone.

Figure 1: Nations with the largest urban populations in the Low Elevation Coastal Zone



[65] Revi, A. (2005), "Lessons from the Deluge: Priorities for multi-hazard risk mitigation in Mumbai", *Economic and Political Weekly,* Vol. XL No. 36, September, pages 3–9.
[66] Adger, Aggarwal, Agrawala et al. (2007), op, cit., page 6
[67] Ibid., page 7.
[68] McGranahan, Gordon, Deborah Balk and Bridget Anderson (2007), "The rising tide: assessing the risks of climate change and human settlements in low-elevation coastal zones", *Environment and Urbanization*, Vol. 19, No. 1, pages 17–37.

Figure 2: Nations with the highest proportion of their urban populations in the Low Elevation Coastal Zone



SOURCE AND NOTES: These figures were prepared by Gordon McGranahan, Deborah Balk and Bridget Anderson from the GRUMP database; see McGranahan, Gordon, Deborah Balk and Bridget Anderson (2007), "The rising tide: assessing the risks of climate change and human settlements in low-elevation coastal zones", *Environment and Urbanization*, Vol. 19, No. 1, pages 17–37. For Figure 2, countries with an urban population of fewer than 100,000 were excluded.

Obviously, only a proportion of those within this zone are at risk from the sea-level rises that are likely within the next 30–50 years. Estimates for sea-level rise vary from 18cm to 59cm up to the end of the 21st century; these will certainly multiply the number of people flooded by storm surges. One estimate has suggested that 10 million people are currently affected each year by coastal flooding and that the numbers will increase under all the climate-change scenarios.[69] The problems with coastal flooding will obviously be much more serious if certain potentially catastrophic events whose probability is uncertain were to happen – for instance the accelerated melting of Greenland's ice sheet or the collapse of the West Antarctic ice sheet.[70]

The latest IPCC Working Group II report notes the particular vulnerabilities to sea-level rise and changes in run-off of large sections of the urban and rural population in heavily populated Asian deltas such as the Ganges-Brahmaputra (that includes Dhaka), the Mekong, the Chang jiang (also known as the Yangtze which includes Shanghai) and the Chao Phraya (with Bangkok). Many other deltas in Asia and Africa also have large urban and rural populations at risk, especially the Nile but also including the Niger (with Port Harcourt) and the Senegal (with Saint Louis[71]) – and, of course, in the Americas the Mississippi (with New Orleans).[72]

There also appears to be increasing population concentrations in low-elevation coastal zones in most nations.[73] China provides the most dramatic example as it is the nation with the largest number of urban

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[69] Nicholls R.J., (2004), "Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios", *Global Environmental Change*, Vol. 14, No. 1, pages 69–86.
[70] Adger, Aggarwal, Agrawala et al. (2007), op, cit.
[71] See Diagne, Khady (2007), "Governance and natural disasters: addressing flooding in Saint Louis, Senegal", *Environment and Urbanization*, Vol. 19, No. 2, pages 552-562.
[72] Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe (2007), "Coastal systems and low-lying areas", Chapter 6 in Parry, Martin, Osvaldo Canziani, Jean Palutikof, Paul van der Linden and Clair Hanson (editors) *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, pages 315-356.
[73] McGranahan, Balk and Anderson (2007), op. cit.

and rural dwellers in the low-elevation coastal zone and it still has a very strong trend towards increasing population concentration in this zone. Increasing trade and market-driven movements, often supported by government incentives, are still attracting people to the coast. The coastal provinces of China experienced a net in-migration of about 17 million people between 1995 and 2000, creating pressures in an already crowded coastal zone.[74]

Many cities in Africa are also at risk from sea-level rise and storm surges. Half of the continent's 37 "million-cities" are within or have parts within the low-elevation coastal zone. Banjul, Lagos and Alexandria are among the cities most at risk (see Box 3) although many others are also likely to face much-increased risks from storms and flooding but because of the lack of local analysis, the scale of these risks has yet to be documented.[75] Many Asian cities are also particularly at risk. Asia has many of the world's largest cities or metropolitan areas that are in the floodplains of major rivers (including those noted above in deltas) and cyclone-prone coastal areas (Bay of Bengal, South China Sea, Japan and the Philippines).

Large sections of Mumbai, Dhaka and Shanghai are only 1 to 5 metres above sea level.[76] Much of central Mumbai is built on landfill, as the city developed on seven islands that became joined into a single land mass over time, as the city expanded. Mumbai is also likely to suffer from more serious storm surges and increased frequency and intensity of extreme weather (cyclones) as a result of climate change. The likely long-term trend of sea-level rise is likely to prove very damaging, as this combined with storm surges may make large areas of the city uninhabitable. Perhaps not surprisingly, it is mostly low-income households living in informal or illegal settlements that face the greatest risks from flooding.

In Latin America, the coastal plain of north-east South America is very low-lying, generating risks for major settlements from north-east Brazil to Venezuela. The coastal zone of Guyana holds 90 per cent of national population and 75 per cent of the national economy; its highest point is 1.5 metres above sea-level with much residential land, including the capital Georgetown, below high-water sea level. In many Caribbean states, between 20 and 50 per cent of the population resides within the low-elevation coastal zone.

There is some evidence that hurricane-force winds will become more frequent and intense, and possibly also that the hurricane belt will move southwards. Highly urbanized coasts most at risk therefore include Vietnam in Asia; Gujarat in west India and Orissa in east India, the Caribbean including major urban settlements like Santo Domingo, Kingston, and Havana and those on Mexico's Caribbean coast and Central America – as we have seen from Hurricane Mitch. A sea-surface temperature rise of 2–4° C, as expected in the Indian Ocean over the century, is expected to induce a 10–20 per cent increase in cyclone intensity.[77] Since cyclone-formation frequency in the Bay of Bengal is about five times that of the Arabian Sea,[78] India's east coast is clearly at more risk. The high concentration of population, especially on the eastern coasts of India and Bangladesh, has led to extremely high vulnerability in this region, leading to very large loss of life and property. The 1999 Orissa super cyclone killed over 10,000 people, devastated buildings, lifeline infrastructure and economic assets across ten coastal and six inland districts, which included a number of towns and cities, due to a mixture of devastating storm surge, cyclonic winds and coastal flooding.[79] Cyclone and storm surge could have a devastating impact on large

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[74] Ibid.

[75] Watson, Robert T., Marufu C. Zinyowera and Richard H. Moss (1997), *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, IPCC Special Report, Cambridge University Press, Cambridge, 527 pages; accessible at http://www.grida.no/climate/ipcc/regional/index.htm.

[76] de Sherbinin, Alex, Andrew Schiller and Alex Pulsipher (2007), "The vulnerability of global cities to climate hazards", *Environment and Urbanization*, Vol. 19, No. 1, pages 39–64; Alam and Golam Rabbani (2007), op. cit.

[77] Aggarwal, D. and M. Lal (2001), *Vulnerability of Indian Coastline to Sea Level Rise*. Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi.

[78] India Meteorological Department (1979), *Tracks of Storms and Depressions in the Bay of Bengal and the Arabian Sea 1877 to 1970*, New Delhi; India Meteorological Department (1996), *Tracks of Storms and Depressions in the Bay of Bengal and the Arabian Sea 1971 to 1990*, New Delhi; TARU (2005) *Disaster Management Plan Blueprint for the Hazira Area Development Committee*, Gandhinagar.

[79] TARU/BMTPC (1998), Rapid Damage Assessment of Cyclone Affected Areas of Kachchh & Saurashtra in Gujarat, Taru, New Delhi.

urban centres including two mega-cities (Mumbai and Chennai) and several million-cities and important ports.[80]

Constraints on water supplies and other key natural resources

IPCC Working Group II noted that, by 2050, annual average river runoff and water availability are projected to increase by 10–40 per cent at high latitudes and in some wet tropical areas, and to decrease by 10–30 per cent over some dry regions in mid-latitudes and in the dry tropics, some of which are presently water-stressed areas. In some places and in particular seasons, changes will differ from these annual figures. Drought-affected areas are likely increase in extent.[81]

In Africa, "by 2020, between 75 million and 250 million people are projected to be exposed to an increase of water stress due to climate change"[82] (high confidence). In Asia, "Freshwater availability in Central, South, East and South-east Asia, particularly in large river basins, is projected to decrease due to climate change which, along with population growth and increasing demands arising from higher standards of living could adversely affect more than a billion people by the 2050s"[83] (high confidence). Any reduction in the availability of freshwater resources caused by climate change will be particularly problematic for those who live in areas already suffering water scarcity or water stress – with poorer groups likely to be most affected.[84] During the last century, mean precipitation in all four seasons of the year has tended to decrease in all the world's main arid and semi-arid regions: Northern Chile, the Brazilian Northeast and Northern Mexico, West Africa and Ethiopia, the drier parts of Southern Africa, and Western China.[85] If these trends continue, water-resource limitations will become more severe in precisely those parts of the region where they are already most likely to be critical.[86]

Many cities and their water catchments will get less precipitation (and have more constrained freshwater sources) – which is particularly problematic for growing cities and large cities already facing serious problems obtaining sufficient freshwater supplies.[87] This implies a need to adapt water-consumption practices and supply systems, as well as drainage systems. But in many instances, this has to be done within systems that already have serious deficiencies. For instance, at least 14 African nations are already facing water stress or water scarcity and many more are likely to join this list in the next 10–20 years.[88] There is already a failure to manage water resources well in much of this region, independent of climate change – where around half the urban population already lacks adequate provision for water and sanitation, although this is linked far more to inadequate governance than to water shortages.[89]

Although agriculture remains the largest user of freshwater resources within virtually all national economies, the water demands from urban enterprises and consumers have become increasingly important in most nations. In addition, many major cities have had to draw freshwater from increasingly distant watersheds, as local surface and groundwater sources no longer meet the demand for water, or as they become depleted or polluted. In many coastal cities, local groundwater supplies have been depleted to the point where saline intrusion limits freshwater supplies.[90]

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[80] GSDMA/TARU (2005), *Gujarat Vulnerability and Risk Atlas*, Gandhinagar; TARU (2005), op. cit.
[81] Adger, Aggarwal, Agrawala et al. (2007), op, cit., page 5.
[82] Ibid., page 8.
[83] Ibid., page 8.
[84] Romero Lankao, P. (2006), "¿Hacia una gestión sustentable del agua? Alcances y límites de la descentralización hidráulica en la ciudad de México" in Barkin, David (editor), *La Gestión del Agua Urbana en México*, UdeG/UAMXochimilco, Mexico.
[85] Folland, C.K., et al. (2001), *Projections of Future Climate Change*, quoted in Wilbanks, Romero Lankao et al. (2007), op. cit.
[86] Rhode, T.E. (1999), "Integrating urban and agriculture water management in southern Morocco", *Arid Lands News Letter,* 45, quoted in Wilbanks, Romero Lankao et al. (2007), op. cit.
[87] Anton, Danilo J. (1993), Thirsty Cities: Urban Environments and Water Supply in Latin America, IDRC, Ottawa, 197 pages; UN Habitat (2006), Meeting Development Goals in Small Urban Centres; Water and Sanitation in the World's Cities 2006, Earthscan, London.
[88] Muller, Mike (2007), "Adapting to climate change: water management for urban resilience ", *Environment and Urbanization*, Vol. 19, No. 1, pages 99–113.
[89] UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.
[90] Hardoy, Mitlin and Satterthwaite (2001), op. cit.; UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.

Around half of the urban population of Africa and Asia lacks provision for water and sanitation to a standard that is healthy and convenient. In Latin America and the Caribbean, more than a quarter lack such provision (Table 5). Hundreds of millions of urban dwellers face great difficulties in getting the water they need, every day; around one billion lack access to good-quality toilets; tens of millions have no access and so defecate in the open or into waste paper or plastic bags ("wrap and throw").[91] Thus, planning for adaptation for urban water supplies has to be done with a recognition of the massive deficiencies in provision and the very large backlog in basic infrastructure that has to be addressed – from the supply of treated water to its provision, then collection once used, and treatment.

Table 5: Urban dwellers lacking adequate provision for water and sanitation in 2000

Region	Lacking water	**Lacking sanitation**
Africa	100–150 million (c.35–50%)	150–180 million (c.50–60%)
Asia	500–700 million (c.35–50%)	600–800 million (c.45–60%)
Latin America and the Caribbean	80–120 million (c.20–30%)	100–150 million (c.25–40%)

SOURCE: UN Human Settlements Programme (2003), *Water and Sanitation in the World's Cities; Local Action for Global Goals,* Earthscan, London, 274 pages. N.B. This report emphasizes that these are "indicative estimates" because most governments do not report on who has "adequate" provision.

The IPCC noted the different ways in which climate variability and change affects urban water supply and sewage systems.[92] Increased temperatures generally mean increased water demand – and if climate change reduces local water sources, this generally leads to increased demand on regional water supplies.[93] Changes in precipitation patterns may lead to reductions in river flows, falling groundwater tables and, in coastal areas, saline intrusion in rivers and groundwater. Detected declines in glacier volumes in parts of Asia and Latin America will lead to reduced river flows at key times of the year – and, for instance, having substantial impacts on water flows to cities located in the Andean valleys (and also reductions in hydro-electric generation).[94] Climate-change-related melting of glaciers could seriously affect half a billion people in the Himalaya–Hindu-Kush region and a quarter of a billion people in China who depend on glacial melt for their water supplies.[95]

The IPCC has also noted the dramatic impacts on water supplies that are likely under extremes of weather that could arise as a result of climate change, particularly drought and flooding. Water-supply abstraction and treatment works are sited beside rivers and are often the first items of infrastructure to be affected by floods. Electrical switchgear and pump motors are particularly at risk. In severe riverine floods with high flow velocities, pipelines may be damaged.[96] Sanitation can also be affected. Flooding often damages pit latrines (and most of Africa's and Asia's urban population relies on pit latrines) and floodwaters are usually contaminated by the overflow from pit latrines or septic tanks – and often sewers too. Toilets linked to sewers also become unusable without a water supply. But most urban centres in sub-Saharan Africa and in Asia have no sewers – or if they do, these serve only a very small proportion of the population.[97] As the IPCC noted, the main significance of sanitation here is that sanitation

[91] UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.
[92] Wilbanks, Romero Lankao et al. (2007), op. cit.
[93] Ibid.
[94] Magrin, G., C. Gay Garcia, D. Cruz Choque, J.C. Giménez, A.R. Moreno, G.J. Nagy, C. Nobre and A. Villamizar (2007), "Chapter 13 – Latin America" in Parry, Canziani, Palutikof, van der Linden and Hanson (editors), op. cit. pages 581-615; Vergara, W. (2005), *Adapting to Climate Change. Lessons Learnt, Work in Progress and Proposed Next Steps for the World Bank in Latin America*, World Bank, LCR Environmentally and Socially Sustainable Development Department Working Paper 25, 55 pages.
[95] Stern, Nicholas (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, 692 pages.
[96] Wilbanks, Romero Lankao et al. (2007), op. cit.
[97] Hardoy, Mitlin and Satterthwaite (2001) op. cit.; UN-Habitat (2003), Water and Sanitation in the World's Cities, op. cit.; UN-Habitat (2006), op. cit.

infrastructures (or the lack of them) are the main determinant of the contamination of urban floodwater with faecal material, presenting a substantial threat of enteric disease.[98]

Box 6: Cities facing serious water shortages

Delhi: The National Capital Region faces a severe water shortfall and is competing with irrigated agriculture upstream. Drinking water is being transported to meet the demands of this city of 15 million, from over 300km, and yet unaccounted-for water losses are over 40 per cent in the city. Rising temperatures and therefore energy demand for cooling, increasing precipitation variability, a lower number of rainy days, an unsustainable mining of groundwater and a heavily polluted river system could make the Delhi mega-urban region, with its projected population of over 30 million, unsustainable, in spite of the rapid growth in its income and wealth.[99]

Mexico City: Buildings and infrastructure are sinking as a result of the over-exploitation of the aquifers under the city. The water-distribution network loses 40 per cent of the water. Although it has a relatively high annual rainfall, Mexico City has to import around a third of its raw water from neighbouring river basins (Cutzamala and Lerma), which also involves pumping this water up nearly 1,000 metres, with very high energy costs.[100] A more intense hydrological cycle is resulting in more severe episodes of drought and floods, which will further constrain poor sectors' access to freshwater[101] and increase the vulnerability of at least 24,000 people located in risk-prone areas.[102]

Predictions can be made about likely changes in precipitation and freshwater availability with considerable confidence for large regions – for instance for Southern Africa – but much less so for individual cities. For cities, knowledge of likely changes is important not only because of the freshwater supplies they need (and the long lead-time for planning and building new supply facilities) but also for how they might affect agriculture and other activities dependent on natural resources, and food supplies and prices. For instance, in India, the most serious climate-change risk to the economy and people is the increased intensity, frequency and geographical coverage of drought. The primary impacts will obviously be in rural areas where agriculture, animal husbandry and, to a lesser extent, forestry and fishing are significantly impacted, leading to cycles of seasonal and distress migration and increasing rural debt.[103] For urban areas, this could mean drinking-water shortages and increases in food and biomass fuel prices that hurt the urban poor. It also has important second-order impacts: increasing seasonal and distress migration from rural areas and reduced demand for secondary goods and services because of depressed agricultural demand.[104] In regions where climate change brings decreasing possibilities for agriculture, local urban centres will suffer from decreases in both local supplies and local farmers' incomes (and thus spending on goods and services within these urban centres).

Generally "urban" and "rural" issues are discussed as if they were somehow separate. But a considerable part of the urban population in low- and middle-income nations derives its livelihoods from producing or selling goods and providing services to rural producers or inhabitants. There are also the obvious rural–urban links for the many locally produced foodstuffs that urban dwellers purchase, and for all industries that rely on crops or forest products as inputs. Urban or peri-urban agriculture often has particular importance, both for food supplies to urban areas and for incomes for their producers, especially where there are markets for high-value-added crops. So support to rural/peri-urban populations and production systems to reduce their vulnerability to climate change is important for urban food supplies and many urban livelihoods and economies – just as protecting urban economies and livelihoods is also important for so many rural households whose livelihoods depend on goods sold to urban populations or whose

[98] Ahern M., R.S. Kovats, P. Wilkinson, R. Few, and F. Matthies (2005), "Global health impacts of floods: epidemiologic evidence", *Epidemiologic Reviews,* Vol. 27, pages 36–46.
[99] Revi 2007, op. cit.
[100] Romero Lankao, P. (2007), op. cit.; Connolly, Priscilla (1999), "Mexico City: our common future?", *Environment and Urbanization*, Vol. 11, No. 1, April, pages 53–78.
[101] Romero Lankao, P. (2006), op. cit.
[102] SMA (Ministry of Environment, Government of the Federal District) (2004), *Estrategia Local de Acción Climática de la Ciudad de México*, SMA, México.
[103] Sainath, S. (2002), *Everybody Loves a Good Drought: Stories from India's Poorest Districts*, Penguin, New Delhi.
[104] Revi (2007), op. cit.

income is in part derived from household members working in urban areas.[105] In regard to other natural resources, many tourist cities on the coast will have their "tourist assets" damaged because of flood damage to coastal reefs and loss of beaches, although experience suggests that tourists will be protected while low-income residents and workers will suffer the most.

Higher temperatures and heatwaves

Most cities in Africa, Asia and Latin America and the Caribbean will experience more heatwaves; for larger, higher-density cities, the temperatures in central "heat islands" can be several degrees higher than in surrounding areas. Many will face more problems with certain air pollutants as concentrations of air pollutants may change in response to climate change because a portion of their formation depends, in part, on temperature and humidity. This has particular importance for Asia and Latin America, which have most of the cities with the highest levels of air pollution. There is less information on the impacts of heat stress in Africa or Latin America but studies undertaken in North America, Asia and Europe found that heatwaves are associated with marked short-term increases in mortality.[106] The European heatwave of 2003 claimed 20,000 lives, mostly among the poor and isolated elderly. In Andhra Pradesh, India, a heatwave killed more than 1,000 people – mostly labourers working outside in high temperatures in smaller urban settlements.[107]

In regard to urban heat islands, higher temperatures occur in urban areas than in outlying rural areas because of diurnal cycles of absorption and later re-radiation of solar energy and (to a much lesser extent) heat generation from built/paved physical structures. These increase the frequency and severity of heat-stress events in cities and can affect the health, labour productivity and leisure activities of the urban population. There is considerable variation in the extent and duration of extreme temperatures between different residential, commercial and industrial buildings and between different neighbourhoods or districts. There are also economic effects, such as the additional cost of climate-control within buildings, and environmental effects, such as the formation of smog in cities and the degradation of green spaces – and increased greenhouse gases if additional demand for cooling is met with electricity generated from fossil fuels.

There is some evidence that the combined effects of heat stress (e.g. urban heat-island effects) and air pollution may be greater than the simple additive effects of the two stresses.[108] There are again different vulnerabilities to the health impacts of climate-related extremes and air pollution within urban areas. Local factors, such as climate, topography, heat-island magnitude, income, access to health services and the proportion of elderly people, are important in determining the underlying temperature–mortality relationship in a population.[109] Winter mortality and morbidity in high-altitude and colder cities depend on the quality of households' home-heating, the health of the populations, and the conditions of prevention and treatment of winter infections.[110]

Other health risks related to climate change

The text above has pointed to a range of health-related risks arising from climate change, including direct risks (e.g. physical hazards from floods, storms, fires and heat stress) and less direct risks (e.g. climate change negatively affecting livelihoods, food supplies or access to water, or exacerbating air-pollution problems). Climate change is also likely to bring:

- an increased burden of diarrhoeal disease;
- increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone

[105] Tacoli, Cecilia (editor) (2006), *The Earthscan Reader in Rural–Urban Linkages*, Earthscan, London, 329 pages. See also Box 8 below on India's "RUrban" transformation, 2000–2050.
[106] Confalonieri et al. 2007, op. cit.
[107] http://www.heatisonline.org/contentserver/objecthandlers/index.cfm?id=3943&method=full
[108] Patz, J. and J. Balbus (2003), "Global climate change and air pollution: interactions and their effects on human health" in Aron, J. and J. Patz (editors), *Ecosystem Change and Public Health*, Johns Hopkins University Press, Baltimore, pages 379–402.
[109] Curriero, F., K.S. Heiner, J. Samet, S. Zeger, L. Strug and J.A. Patz (2002), "Temperature and mortality in 11 cities of the Eastern United States", *American Journal of Epidemiology*, 155, pages 80–87.
[110] Carson, C., S. Hajat, B. Armstrong and P. Wilkinson (2006), "Declining vulnerability to temperature-related mortality in London over the twentieth century", *American Journal of Epidemiology*, Vol. 164, No. 1, pages 77-84.

related to climate change;

- altered spatial distribution of some infectious disease vectors – for instance as warmer average temperatures permit an expansion of the area in which many "tropical" diseases can occur.

Expansion is likely in the area in which the mosquitoes that spread malaria, dengue fever and filariasis can survive and breed.[111] Note in particular the rapid spread of dengue fever in many nations in recent years, as the *aedes* mosquito adapts to urban conditions. In India, malaria is expected to expand its range horizontally and vertically, from its currently endemic range in eastern and north-eastern India to western and southern India.[112] Given that Indian cities have become major reservoirs of vector-borne diseases such as malaria and dengue fever, it can be expected that the morbidity risks will increase. However, all the above health risks are present for much of the urban population without climate change.

Sometimes, where extreme weather events generate new health hazards and cause disruption to public health services they can lead to increased disease incidence. Hurricane Mitch in Central America in 1998 resulted in increases in cases of malaria, dengue fever, cholera and leptospirosis.[113] Populations with poor sanitation infrastructure and high burdens of infectious disease often experience increased rates of diarrhoeal diseases, cholera and typhoid fever after flood events. The transmission of enteric pathogens is generally higher during the rainy season.[114]

The particular problems facing urban populations in small island nations

The IPCC Working Group II summary noted the following with very high confidence: *"Small islands… have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events.*

"Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. Climate change is projected by mid-century to reduce water resources in many small islands e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low rainfall periods.

"Reduced rainfall in summer is projected for many islands in the Caribbean, so that it is unlikely that demand would be met during low rainfall periods. Increased rainfall in winter is unlikely to compensate due to lack of storage, and high runoff during storms.

"Tourism is the major contributor to GDP and employment in many small islands. Sea-level rise and increased sea water temperature will cause accelerated beach erosion, degradation of coral reefs and bleaching. In addition, loss of cultural heritage from inundation and flooding reduces the amenity value for coastal users. Whereas a warmer climate could reduce the number of people visiting small islands in low latitudes, it could have the reverse effect in middle and high latitude islands. However, water shortages and increased incidence of vector-borne diseases may also deter tourists."

Many small islands are at risk from extreme weather and a range of other environmental hazards independent of climate change – but many of these are likely to be exacerbated by climate change. Many small islands are at risk from coastal, river and rain-induced flooding, tropical cyclones and storm

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[111] Adger, Aggarwal, Agrawala et al. (2007), op, cit.; WHO (1992), *Our Planet, Our Health*, World Health Organization, Geneva.

[112] Bhattacharya, Sumana, C. Sharma et al. (2006), "Climate change and malaria in India", NATCOM Project Management Cell, National Physical Laboratory, New Delhi, *Current Science*, Vol. 90, No. 3, 10 February.

[113] Vergara (2005), op cit., page 14.

[114] Nchito, M., P. Kelly, S. Sianongo, N.P. Luo, R. Feldman, M. Farthing, and K.S. Baboo (1998), "Cryptosporidiosis in urban Zambian children: an analysis of risk factors", *American Journal of Tropical Medicine and Hygiene*, Vol. 40, No. 59, pages 435–437; Kang, G., B.S. Ramakrishna, J. Daniel, M. Mathan and V. Mathan (2001), "Epidemiological and laboratory investigations of outbreaks of diarrhoea in rural South India: implications for control of disease", *Epidemiology of Infections* Vol. 127, pages 107-112, quoted in Confalonieri et al. (2007), op. cit.

surges.[115] Many small island nations in the Caribbean face high risks from cyclones. Many have a high proportion of their economy and urban population in urban centres on the coast – for instance, close to two-thirds of the population in the Caribbean lives in urban areas. Most of these small islands have economies and much of their populations' livelihoods at risk from the disruptions that extreme-weather events bring, including a reliance on imports for many essential goods. Many also rely heavily on international tourism.

Small islands, by definition, have limited physical size and much of their land area close to coasts. This usually means limits in adaptation options – for instance in developing new activities or moving vulnerable settlements away from coasts. Many small islands also have high levels of natural-resource exploitation and urbanization occurring in zones at high risk from disasters (often with coastal developments also increasing risks – for instance as mangroves and wetlands are displaced by residential or tourist developments). Many are already facing serious freshwater shortages – and climate change may exacerbate this. Many of the larger-population small island nations also have cities with a significant proportion of their population living in informal or illegal settlements, often on sites at risk from flooding or landslides.

Identifying drivers

Three drivers of increased vulnerability to climate variability, change and hazards in urban areas are considered in this subsection: the drivers of urbanization and urban change, the weaknesses and incapacities of governments, and the development and expansion of cities in high-risk sites. The key here is to understand how the processes that drive or shape urban change create risk to a range of hazards, including those that climate change is likely to create or exacerbate.

What drives urban change?[116]

Understanding what causes and influences urban change within any nation is complicated. Consideration has to be given to changes in the scale and nature of the nation's economy and its connections with neighbouring nations and the wider world economy – also to decisions made by national governments, national and local investors and the 30,000 or so global corporations that control such a significant share of the world's economy. Urban change within all nations is also influenced by the structure of government (especially the division of power and resources between different levels of government), and the extent and spatial distribution of transport and communications investments. The population of each urban centre and its rate of change are also influenced not only by such international and national factors but also by local factors related to each very particular local context – including the site, location and natural-resource endowment, the population's demographic structure, existing economy and infrastructure (the legacy of past decisions and investments) and the quality and capacity of public institutions.

The immediate cause of urbanization[117] is the net movement of people from rural to urban areas. The main underlying cause is the concentration of new investment and economic opportunities in particular urban areas. Virtually all the nations that have urbanized most over the last 50–60 years have had long periods of rapid economic expansion and large shifts in employment patterns from agricultural/pastoral activities to industrial, service and information activities.[118] In low- and middle-income nations, urbanization is overwhelmingly the result of people moving in response to better economic opportunities in the urban areas, or to the lack of prospects in their home farms or villages. The scale and direction of people's movements accord well with changes in the spatial location of economic opportunities. In general, it is cities, small towns or rural areas with expanding economies that attract most migration.[119] By 2004, 97 per cent of the world's GDP was generated by industry and services, most of which comes from urban-based enterprises, and around 65 per cent of the world's economically active population was

[115] Tompkins, Emma L., Sophie A. Nicholson-Cole, Lisa-Ann Hurlston, Emily Boyd, Gina Brooks Hodge, Judi Clarke, Gerard Gray, Neville Trotz and Lynda Varlack (2005), *Surviving Climate Change in Small Islands – A Guide Book*, Tyndall Centre for Climate Change Research, Norwich, 128 pages.
[116] This section draws on Satterthwaite (2007), *The Transition to a Predominantly Urban World*, op. cit.
[117] Urbanization is understood to be an increase in the proportion of national populations living in urban areas.
[118] Satterthwaite (2007), "In pursuit of a healthy urban environment", op. cit.
[119] There are important exceptions, such as migration flows away from wars/conflicts and disasters.

working in industry and services. Most of the world's largest cities are in the world's largest economies. Political changes have had considerable importance in increasing levels of urbanization in many nations over the past 50–60 years, especially the achievement of political independence (which often also meant the dismantling of apartheid-like colonial controls on the rights of inhabitants to live or work in urban areas in many nations) and the building of government structures. These had particular importance for much of Asia and Africa but had much less effect in most nations from the 1980s onwards.

Do climate-change specialists and disaster specialists understand what drives and shapes urban change? With a few honourable exceptions, the literature suggests that they have a simplistic, often stereotyped "urban population explosion" or "rural-push/urban-pull" view of urban change. This often fails to consider why urbanization is taking place, what drives people to concentrate in specific urban locations and what particular processes make the population of each urban centre (or particular groups within it) vulnerable. For instance, in one paper rich in insights about urban disasters and vulnerability,[120] there is a very short section on the increase in the urban population in "developing countries" (drawing mostly on very out-of-date statistics) and no discussion on the great variation in the scale and nature of urban development between nations and within nations (and how this has changed over time) and of what causes urbanization. Another paper looking at urbanization and natural disasters in the Mediterranean simply refers to urbanization being caused by push and pull factors, the structure of the economy and the stage of economic development,[121] as if this explained the scale and nature of urbanization within each nation. Both these papers and many others seem to take as given the fact that all nations are urbanizing (which is not true) and that all urban centres face rapid population increases (which is also not true, as an analysis of urban change in any nation between two censuses shows). There are many large cities, small cities and small towns in Africa, Asia and Latin America that do not have rapidly growing populations. Mexico City, São Paulo, Rio de Janeiro, Buenos Aires, Calcutta and Seoul had more people moving out than moving in during their most recent inter-census period.[122]

Aggregate urban statistics are often interpreted as implying comparable urban trends across the world or for particular continents. But they obscure the diversity between nations and hide the particular local and national factors that influence these trends. Recent censuses show that the world today is actually less urbanized and less dominated by large cities than had been anticipated. Analyses of urban change within any nation over time show the rising and falling importance of different urban centres, the spatial influence of changes in governments' economic policies (for instance, from supporting import substitution to supporting export promotion) and of international trade regimes, the growing complexity of multi-nuclear urban systems in and around many major cities – and the complex and ever-shifting patterns of migration from rural to urban areas, from urban to urban areas and from urban to rural areas. International immigration or emigration has strong impacts on the population size of particular cities in most nations. But it is not only changing patterns of prosperity or decline that underpin these flows – many cities have been affected by war, civil conflict or disaster, or by the arrival of people fleeing these events.

If our concern is what makes urban centres and populations at risk from climate change, we need to understand why urban populations (or sub-groups within a population) often concentrate in high-risk areas and why urban processes can greatly magnify the size of the risk and the population at risk. It is common to see urbanization listed as a "driver" of vulnerability but this is questionable for two reasons: first, in some locations, urbanization is associated with much-reduced vulnerability to extreme weather events and other environmental hazards; and, second, urbanization is not so much a driver as a result of other drivers. Unlike other areas of climate-change research (e.g. agricultural vulnerability), no systemic methodologies and studies have been developed to understand urban vulnerability in the context of multiple stressors, to address the determinants of vulnerability and poverty in urban areas, and to explore the constraints and windows of opportunity (e.g. innovative approaches) to increase the adaptive capacity

[120] Quarantelli, Enrico (2003), "Urban vulnerability to disasters in developing countries: managing risks" in Kreimer, Alcira, Margaret Arnold and Anne Carlin (editors), *The Future of Disaster Risk; Building Safer Cities*, conference papers, World Bank, Washington DC, pages 237–262.
[121] Brauch, Hans Gunter (2003), "Urbanization and natural disasters in the Mediterranean; population growth and climate change in the 21st century" in Kreimer et al. op. cit., pages 170–183.
[122] Satterthwaite (2007), *The Transition to a Predominantly Urban World*, op. cit.

or resilience of the urban poor.[123]

Although rapid urban growth is often seen as "a problem", it is generally the nations with the best economic performance that have urbanized most in the last 50 years.[124] In addition, perhaps surprisingly, there is often an association between rapid urban change and better standards of living. Not only is most urbanization associated with stronger economies but, generally, the more urbanized a nation, the higher the average life expectancy and literacy rate, and the stronger the democracy, especially at local level. Many of the largest cities may appear chaotic and out of control, but most have life expectancies and provision for piped water, sanitation, schools and health care that are well above their national average – even if the aggregate statistics for each large city can hide a significant proportion of their population living in very poor conditions. Some of world's fastest-growing cities over the last 50 years also have among the best standards of living within their nation.[125] A concern for development and for reducing urban populations' vulnerability to risks (including those associated with climate change) should include a focus not only on large or fast-growing cities but also on smaller urban centres and urban centres that are not growing rapidly, since these contain a high proportion of the urban population.[126]

There is often an assumption that agriculture should be considered as separate from or even in opposition to urban development, and that "rural" development is needed to help reduce rural–urban migration. But successful rural development often increases rural–urban migration as higher-value crops and higher incomes among rural populations increase demand for goods and services in urban centres.[127] Many major cities first developed as markets and service centres for farmers and rural households, and later developed into important centres of industry and/or services.[128] Many such cities still have significant sections of their economy and employment structure related to forward and backward linkages with agriculture.[129]

Do urban specialists concern themselves with urban populations' vulnerability to extreme weather events? Again, with a few honourable exceptions, the literature suggests that they do not – although this is part of a wider failure among urban specialists to give much consideration to the life- or health-threatening risks to which urban populations (or particular groups within urban populations) are exposed in their homes, neighbourhoods and workplaces.[130] Why have metropolitan, city and municipal government structures not developed in step with rapid urban growth? This is more easily explained in the many cities and smaller urban centres that lack a prosperous economic base. But a large proportion of the urban population most at risk from climate change lives in urban centres that have had very rapid economic growth. The main reason is the failure to develop local government structures and local

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[123] Romero Lankao (2007), op. cit.

[124] Satterthwaite (2007), *The Transition to a Predominantly Urban World*, op. cit. A World Bank paper published in 2000 (Fay, Marianne and Charlotte Opal (2000), *Urbanization without Growth: A Not so Uncommon Phenomenon,* World Bank, Washington DC) claimed that sub-Saharan Africa was an exception in that it had urbanized rapidly during the 1990s without economic growth, but the validity of this paper's conclusions must be in question when it had no census data for any African nation for 2000 (it relied on projections for all urban populations in 2000). See Potts, Deborah (2006), "Urban growth and urban economies in Eastern and Southern Africa: Trends and Prospects" in Deborah Fahy Bryceson and Deborah Potts (editors) *African Urban Economies: Viability, Vitality or Vitiation?*, Palgrave Macmillan, Basingstoke, pages 67–98.

[125] Examples are Curitiba and Porto Alegre, both among the most rapidly growing cities in Latin America over the last 50 years, both with high standards of living: Menegat, Rualdo (2002), "Participatory democracy and sustainable development: integrated urban environmental management in Porto Alegre, Brazil", *Environment and Urbanization*, Vol. 14, No. 2, pages 181–206; also Rabinovitch, Jonas (1992), "Curitiba: towards sustainable urban development", *Environment and Urbanization*, Vol. 4, No. 2, October, pages 62–77.

[126] Satterthwaite, David (2006), Outside the Large Cities: The Demographic Importance of Small Urban Centres and Large Villages in Africa, Asia and Latin America, Human Settlements Discussion Paper; Urban Change–3, IIED, London, 30 pages.

[127] Satterthwaite, David and Cecilia Tacoli (2003), The Urban Part of Rural Development: The Role of Small and Intermediate Urban Centres in Rural and Regional Development and Poverty Reduction, Rural–Urban Working Paper 9, IIED, London, 64 pages. See also a great range of case studies on rural–urban linkages in Tacoli (2006), op. cit.

[128] Hardoy, Jorge E. and David Satterthwaite (1989), *Squatter Citizen: Life in the Urban Third World*, Earthscan, London, UK, 388 pages; Satterthwaite and Tacoli (2003), op. cit.

[129] See Satterthwaite and Tacoli (2003), op. cit.; also Benjamin, Solomon (2000), "Governance, economic settings and poverty in Bangalore", *Environment and Urbanization*, Vol. 12, No. 1, April, pages 35–56.

[130] Hardoy, Mitlin and Satterthwaite (2001), op. cit.

governance systems that act "in the public good" to reduce risk (and vulnerability). Box 7 highlights the complex interactions between economic development and eco-system change in the coastal zone of the Gulf of Mexico, much of which is increasing vulnerability to some of the likely impacts of climate change in both the USA and Mexico.

Box 7: Economic development and eco-system change in the Gulf of Mexico

The coastal states around the Gulf of Mexico are home to more than 55 million people – and have many critical eco systems such as wetlands, sea grass beds, mangroves, barrier islands, sand dunes, coral reefs and marine forests. These are obviously influenced by the heavy concentration of economic activities – petroleum production, fisheries, agriculture, forestry and tourism. The Gulf concentrates a high proportion of US offshore oil production and of Mexico's total oil production and the oil and gas industry supports an enormous complement of land-based companies and facilities including chemical production, oil field equipment dealers, cement suppliers, caterers, divers, platform fabrication yards and shipyards. The Gulf coastal fisheries are almost entirely dependent on estuarine wetlands – and wetlands are an important natural buffer for storm surges, while also having many important ecological functions, including those related to fisheries and to water quality. Almost 1 million hectares of coastal mangroves were destroyed on the Mexican Gulf Coast between the 1970s and early 1990s.[131] The main drivers for wetland conversion in Mexico are large-scale tourism development, urbanization, and agriculture. In addition, wetlands are extremely sensitive to sea level rise; adaptation should mean maintaining their functions and productivity and for some, adaptation is only possible if there is room for them to migrate inland. Or space for the creation of new wetlands to compensate for those that cannot migrate inland due to topographical or other natural constraints.

SOURCE: Levina, Ellina, John S. Jacob, Luis E. Ramos and Ivonne Ortiz (2007), *Policy frameworks for Adaptation to Climate Change in Coastal Zones: The Case of the Gulf of Mexico*, Paper prepared for the OECD and International Energy Agency, 68 pages.

The other urban issue that needs highlighting is that many of the regions with the most rapid urban growth (and the largest in-migration flows) are coastal areas at risk from sea-level rise and the likely increase in intensity and frequency of extreme weather events. The example from China of the very large migration flows towards cities in coastal areas was given above. The dynamics behind this will be very difficult to change – and there is also a high potential for government policies aiming to do so to cause serious damage the economic prospects of low-income nations and the livelihood opportunities for low-income populations. In virtually all nations, it is where private investments and enterprises choose to concentrate that drives most urbanization.[132]

The challenge facing national governments is how to encourage and support patterns of private investment within national boundaries that are less concentrated in high-risk sites – just as all city governments also have to address this, within their own local jurisdictions. This is not easily done. It is also best done with the kind of long-term perspective (several decades long) that all political systems find difficult. This may be done in ways that damage economic prospects – for instance as the choice of "safer" city sites favoured with incentives and infrastructure investments is determined by political factors, not a careful assessment of where these are most needed.[133] Perhaps more worrying is the likely emergence in some nations of government measures to address the effects of this (trying to control population movements to high-risk sites rather than the private investment flows that underpin these movements) – in effect a system of apartheid-like controls on the rights of people to move within their national boundaries justified by the need to make urban patterns less vulnerable to climate change. Some evidence for this can be seen already in India in regard to which residential areas are at risk from new coastal-zone regulations limiting developments close to the sea. This can also be seen in inappropriate government policies after disasters, which did not allow low-income households to return to their

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[131] Yanez-Arancibia, A. and J.W. Day (2004), "The Gulf of Mexico: towards an integration of coastal management with large marine ecosystem management", *Ocean and Coastal Management* Vol. 47, pages 537-563, quoted in Levina, Ellina, John S. Jacob, Luis E. Ramos and Ivonne Ortiz (2007), *Policy frameworks for Adaptation to Climate Change in Coastal Zones: The Case of the Gulf of Mexico*, Paper prepared for the OECD and International Energy Agency, 68 pages.

[132] This is referring specifically to urbanization understood to be increase in the proportion of the population living in urban centres.

[133] Note the long history of government policies to promote the growth of smaller urban centres or "undeveloped regions" that have been ineffective and often very expensive.

settlements – and with land-use over time transferred to higher-income residential, commercial or industrial use. The result is increased inequality and social tension without a reduction in disaster exposure. One recent example of this is the costal buffer zone established in Sri Lanka, post-Tsunami, forcing the relocation of villages, disrupting livelihoods and generating social tensions, while at the same time tourist businesses have expanded their operations into "vacant" land.

Box 8: India's RUrban transformation, 2000–2050

Large sections of India's rural and urban population are at risk from a wide range of natural hazards (including droughts, floods, cyclones, storm surges, earthquakes and landslides) and human-made hazards (for instance, fire, and road and chemical accidents). Rapid population growth, high densities, poverty and large differentials in the population's access to good-quality housing, infrastructure and public services have increased vulnerability to such hazards, especially in urban centres. Climate-change risk is expected to increase the frequency and intensity of current hazards, increase the number of extreme events and spur the emergence of new hazards such as sea-level rise. Thus, it is important to understand ongoing transformation processes that are rapidly altering India's urban landscape. This includes changing livelihood opportunities and income and wealth distributions that in turn alter the vulnerability profiles of many urban communities and stakeholder groups and their capacity to adapt to climate change.

India will experience one of the most dramatic settlement transitions in history over the next 40–50 years as its urban population grows from about 300 million to over 700 million.[134] By 2007, India had around 30 per cent of its population living in urban areas but, given a total population of over 1.1 billion, its urban population is one of the world's largest – even exceeding that of the USA.

Climate-change risk to India needs to be seen in the perspective of an ongoing three-part transition: a demographic transition that will see India's population stabilizing at around 1.6 billion in the 2060s; a *RUrban* transition, which will see an addition of around 500 million people to an estimated 7,000–12,000 urban settlements over this period; and an environmental transition as the "brown" (environmental health) agenda is accompanied by the growing importance of the "green" (e.g. climate change) agenda. By 2025, three mega-urban regions, Mumbai–Pune (50 million), Delhi National Capital Region (over 30 million) and Kolkata (20 million), will be among the world's largest urban concentrations.[135] By this time, India could have the world's largest urban population *and* the world's largest rural population.

Urban India overtook rural India in its contribution to GDP in the late 1990s, despite having less than 30 per cent of the national population. This contribution to GDP has increased, with rapid economic growth in the city services and manufacturing sectors, post-2000; agriculture now accounts for only 18 per cent of India's GDP. Average per capita incomes in urban areas are now over three times those in rural areas.[136] But agriculture still provides livelihoods for close to 60 per cent of the population, as well as providing the biomass and ecosystem services that enable city metabolisms to function. The importance of supporting rural livelihoods, agriculture and ecological services is further increased, if climate-change induced disruptions are to be coped with.[137]

Climate change could catalyse the ongoing agrarian crisis in rural India in unexpected ways,[138] causing rapid rural-to-urban migration, driven by the increased intensity and frequency of extreme events and the expansion of drought in semi-arid areas, drought and flooding in the very dense Indo-Gangetic and Brahmaputra plains, and flooding and drought in the coastal plains.[139] These scenarios have been only broadly articulated, and not systematically investigated in fine-grained GIS-linked models,[140] so most projections on this are only speculative. But India's future social and political stability will require a more nuanced, detailed and geographically explicit understanding of these risks.[141]

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[134] Hughes, B. and E.E. Hillenbrand (2006), *Exploring and Shaping International Futures*, Paradigm, London.
[135] Dyson, T. and P. Visaria (2004) "Migration and urbanisation: retrospect and prospect" in Dyson, T., R. Cassen and L. Visaria (editors), *Twenty-First Century India, Population, Economy, Human Development and the Environment*, Oxford University Press, New Delhi; Census of India (2006) *Population Projections for India and States 2001–2026*, New Delhi.
[136] CSO (2006), *National Accounts Statistics*, New Delhi, Central Statistical Organisation; RBI (2006), *Handbook of Indian Economic Statistics*, Reserve Bank of India, Mumbai.
[137] Revi, A., S. Prakash and R. Mehrotra (2006), "Goa 2100: the transition to sustainable design", *Environment and Urbanization,* Vol. 18, No. 1, pages 51–65.
[138] Sainath (2002), op. cit.
[139] Gosain, Rao and Basuray (2006), op. cit.; Mall, R.K., Akhilesh Gupta, Ranjeet Singh et al. (2006), "Water resources and climate change: an Indian perspective", *Current Science*, Vol. 90, No. 12, pages 1610–1626; Ramesh, R. and Yadava, M.G. (2005), "Climate and water resources of India", Physical Research Laboratory, Ahmedabad, *Current Science*, Vol. 89, No. 5, 10 September.
[140] Rupa Kumar, Sahai, Kumar et al. (2006), op. cit.
[141] De Vries, Revi, Bhat et al. (2007), op. cit.

Climate-change-induced drought and resource conflict may force the pace of rural–urban migration over the next few decades. Alternatively, severe stresses induced in urban areas due to a mix of water scarcity, breakdown of environmental services, flooding and consequent water-borne disease and malaria epidemics combined with a rapid rise in health expenditures could maintain the low current level of rural–urban migration. Maintaining two-way flows of food, biomass, water, livelihoods, products and services across the *RUrban* continuum will be crucial to India's development and medium-term sustainability. Climate-change adaptation in both cities and the rural economies and systems in which they are embedded is an undiscovered near-term policy concern – and one that is also intimately connected with livelihoods and drought, biomass and energy security.[142]

SOURCE: Revi, Aromar (2007), *Climate Change Risk: A Mitigation And Adaptation Agenda For Indian Cities*, Paper prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience, Taru, New Delhi, 23 pages. A condensed version of this will be published in *Environment and Urbanization* Vol. 20, No. 1, 2008.

Government roles

Urban governments should have a key role as risk reducers for climate change, by:

- providing infrastructure and services (perhaps with some contracted to private enterprises or non-government organizations);
- guiding where development takes place – for instance influencing where urban settlements develop and where they do not and what provision they have to avoid floods, fires, etc;
- regulating building design and construction (including support and training for builders, especially those who are active in building within low-income settlements);
- regulating hazardous activities that can produce disasters (including industries and transport);
- influencing land availability (through land-use regulations, zoning and bureaucratic procedures for buying or obtaining land and what can be built on it) – the quality of land-use management influences the proportion of poorer groups having to live on hazardous or disaster-prone sites;
- encouraging and supporting household/community action that reduces risk (for instance better-quality housing, safer sites, good infrastructure and good disaster preparedness);
- providing "law and order" which should also act to protect low-income groups from risk;
- coordinating and supporting links between disaster avoidance and disaster preparedness – for instance ensuring that all tasks above integrate with agencies responsible for disaster response.

Where urban governments fulfil these key roles, levels of risk for their populations and economies are much reduced, and urbanization is associated with much lowered risks. But where urban governments only partially fulfil these roles – or fail to fulfil them – levels of risk are much increased.

The vulnerabilities of so much of the urban population in Africa, Asia and Latin America and the Caribbean to environmental risks, including those related to climate change, are mainly to do with lack of appropriate investment and action. This is also related to how so many local politicians and city-government personnel view "the poor" and the areas where they live ("slums", informal settlements) as "the problem" rather than the adaptation of key parts of the city's economy and labour force to the lack of better alternatives. If local governments or higher levels of government see their path to economic success as bulldozing or otherwise destroying "slums", or through major infrastructure programmes that displace large sections of the poor population, this will generally be increasing poverty and increasing poorer groups' vulnerability as they move to other areas at risk because these are the only areas where they can get housing or land for housing.

Cities and high-risk sites

IPCC Working Group II noted that rapid urbanization in most low- and middle-income nations is often in relatively high-risk areas, and that this is placing an increasing proportion of those nations' economies and populations at risk.[143] The issue then is why so many cities are on dangerous sites in regard to risks from storms and floods, which happened completely independent of climate change – but climate change has increased the level of risk and the number of people at risk. Four reasons can be suggested for this.[144]

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[142] Revi, A. et al. (2006), *Long Range Macro-dynamics of Indian Urbanization in a Globalizing World*, conference proceedings on India and China in a Global Perspective, April, New School, New York.
[143] Wilbanks, Romero Lankao et al. (2007), op. cit.
[144] This section draws on Hardoy, Mitlin and Satterthwaite (2001), op. cit.

1. "Dangerous" sites were attractive to those who originally founded and developed a city – for instance, because of a good river or sea harbour, a strategic location in regard to trade or territorial control, a ready supply of freshwater or a fertile delta. Most of the world's major cities are on the coast or beside major rivers because they were already important urban centres before railways, new roads and air transport changed transport systems. Most relied on river or sea ports as their main transport and communication link with other places – and, of course, ocean transport is still a key part of the increasingly globalized economy.
2. The original city site may have been safe, but the city has outgrown this site and expanded onto land that is at risk – for instance onto floodplains or up unstable hills or mountains.[145]
3. Once a city has developed, it rarely disappears, even if it experiences some disastrous flood or earthquake – because there are too many individuals, enterprises and institutions with an interest in that city's economy.
4. In most cities at risk from floods, the wealthier groups and most formal enterprises do not face serious risks.

The spatial distribution of urban populations in any nation is not the result of any careful plan to guide urban expansion to "safe" sites. The main driver of city expansion (or stagnation or contraction) is where new or expanding private enterprises choose to concentrate (or avoid). This is also largely true for how each individual urban centre develops – as the localities within and around the urban centre with the most rapidly growing populations are associated with where new or expanding economic activities concentrate – although the physical growth of the urban centre is also influenced by where lower-income groups can (or cannot) get accommodation or land on which housing can be built.[146]

So, in seeking to understand the links between city development and risk from climate change, one of the key issues is – to what extent are private enterprises influenced in their choice of location by risks related to climate change? Obviously, formal-sector private enterprises will not generally invest in sites that are risky – unless the risk of loss can be reduced by insurance or by the risk not actually threatening their production (it is particular geographic areas and particular population groups – usually low-income groups – that are most at risk). In addition, if risks from climate change are seen as distant threats that may affect city sites 20 or 50 or more years in the future, this will not provide much discouragement to invest, especially in successful cities. Dhaka, Mumbai and Shanghai have attracted much private investment, despite their vulnerability to storms and sea-level rise.

More important is the potential impact on the urban economy (and employment opportunities) and on the local government's tax base if companies and corporations move, when risk levels increase – or after some particular extreme weather event. Even if such enterprises are not directly affected by an extreme weather event, the indirect effects – electricity, water supplies or climate-sensitive inputs disrupted, the delay in deliveries of key inputs or difficulties in shipping goods to customers, inconvenience to senior staff – may encourage movement elsewhere or the choice of new locations when enterprises expand.

Government and the public good

The justification for having city and municipal governments is that only they can act to address certain key issues in regard to the public good – for instance ensuring provision of infrastructure and services essential for health and economic success and controlling or regulating the actions and activities of individuals, households or enterprises that are dangerous or that transfer risks or costs to others. This is not to imply that it is city governments (or higher levels of government) that needs to provide all infrastructure and services or even undertakes all the needed policing of rules and regulations – but they have to provide and fund the legal and institutional framework that ensures this with accountability to city populations (usually achieved through city governments overseen by elected politicians).

For climate change, locally accountable government institutions acting "in the public good" have particular importance for five reasons.

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[145] See Hardoy, Mitlin and Satterthwaite (2001), op. cit.

[146] Torres, Haroldo, Humberto Alves and Maria Aparecida de Oliveira (2007), "São Paulo peri-urban dynamics: some social causes and environmental consequences", *Environment and Urbanization*, Vol. 19, No. 1, pages 207–233.

1. Many of the needed measures are public goods in the sense that they will benefit populations including future residents and others that do not contribute to these public goods. Without government action, such goods will be underprovided.
2. The appropriateness of the regulatory framework for land use, infrastructure and buildings will have a huge influence on the extent of appropriate adaptation to climate change – and within this "appropriateness" is the need for such measures not to disadvantage lower-income groups and not to draw investment away from other needed tasks (or run up large debt burdens).
3. There are many no-cost or low-cost measures which if taken now can help to ensure that any rapidly growing city builds into its growth process (and physical and infrastructure expansion) greater resilience. Markets and most individual and community initiatives will not act to reduce risks that are far in the future – but appropriate incentives and controls can make them act on these, without high costs. Most urban disasters have 20–30-year processes of risk accumulation that need to be identified and acted on.
4. There are very large economies of scale and proximity from city-wide action: the total cost of all households and enterprises making provisions for themselves would be much higher and much less effective.
5. Reliance on market mechanisms such as insurance or the capacity to purchase safe housing to produce the needed changes will not serve those unable to access the formal housing market or to afford insurance – which in urban centres in low- and middle-income nations means most of the population and most enterprises.

An obvious example of the need for government to act "in the public good" is measures to stop development on a floodplain, or some other area where development would increase the whole urban centre's vulnerability to the impacts of climate change. Those who own the land may want to develop it, and the state may need to step in to represent the public interest. However, if less well-off residents currently occupy the land, there is a danger that compensation will be insufficient, and even that the "public interest" would not be deployed by evicting them. The time dimension is important in such examples, since developers or early settlers will be thinking short term, but are setting in place infrastructure and settlement patterns for the long term.[147]

Of course, the possibilities of city governments ensuring "the public good" also relate to the policies and practices of higher levels of government, and these have rarely provided adequate or appropriate support for the development of local competence and capacity.[148] Those possibilities are further limited by the reluctance or refusal of so many development-assistance agencies to engage with urban development and, in their support for "good governance", to recognize the importance of "good local governance".[149] However, it is also necessary to recognize the complexities of changing political and institutional systems fast enough to cope with such rapid change. The development of more competent, capable and accountable metropolitan, city and municipal governance structures able to address environmental risks in today's high-income nations was a slow and highly contested process. It was generally underpinned by greater economic prosperity than is evident today in most low- and middle-income nations. The political and institutional constraints on national and local governments being able to develop appropriate policies and measures for climate-change adaptation are still not recognized in much of the literature on adaptation.

Identifying trends

Certain trends described above have obvious implications for the topic of this paper:

- rapidly increasing urban populations – and rapidly increasing numbers of people living in informal settlements lacking provision for basic infrastructure and services;
- rapidly increasing concentrations of economic activities and investments in urban areas – with

[147] There are examples of city governments that have combined watershed protection with measures to improve conditions for those living in informal settlements in these areas – see van Horen, Basil (2001), "Developing community-based watershed management in Greater São Paulo; the case of Santo André", *Environment and Urbanization*, Vol. 13, No. 1, pages 209–222.

[148] There are some important exceptions to this, as discussed in Section V.

[149] Satterthwaite (2001), op. cit; Crespin, Julie (2006), "Aiding local action; the constraints faced by donor agencies in supporting effective, pro-poor initiatives on the ground", *Environment and Urbanization*, Vol. 18, No. 2, pages 433–450.

increasing concentrations in coastal areas in many nations;
- most of the growth in the world's population over the next 10–20 years being likely to happen in urban centres in low- and middle-income nations.[150]

In regard to trends in climate in urban areas:
- There is evidence of water stress affecting increasing numbers of urban centres and their surrounding regions. In some regions, this is linked to long-term trends in decreased precipitation or to reduced river flows. But, in most regions, the contribution of climate change is not known and, at least at present, is likely to be more the result of rapidly growing demand and inadequate water management.
- The frequency of more intense rainfall events in many parts of Asia has increased, causing severe floods, landslides, and debris and mud flows while the number of rainy days and total annual amount of precipitation has decreased.[151] However, there are reports that the frequency of extreme rainfall in some countries has exhibited a decreasing tendency.[152] The growing number of urban disasters caused by extreme weather events is consistent with what the IPCC predicts – but here too it is difficult to separate the relative contribution of climate change from other factors. In part, this is because of the growth in urban populations in high-risk sites.
- The frequency and intensity of tropical cyclones originating in the Pacific have increased over the last few decades.[153] In contrast, the number of cyclones originating from the Bay of Bengal and Arabian Sea has fallen since 1970 but their intensity has increased.[154] In both cases, the damages caused by intense cyclones have risen significantly in the affected countries, particularly India, China, the Philippines, Japan, Vietnam and Cambodia, Iran and the Tibetan Plateau.[155]
- There is evidence of significantly longer heatwave durations observed in many countries.
- There is evidence of sea-level rise in and around many coastal cities, and evidence of impacts related to sea-level rise – for instance receding coasts.

Trends in urban disasters associated with extreme weather events[156]

There is a clear upward trend in the frequency of large disasters arising from natural events from 1950 to 2005 and this upward trend is entirely due to weather-related events; there is also a rapid increase in both economic losses and in insured losses from weather related disasters, 1950-2005.[157] 2007 is likely to have the largest number of disasters for any year on record – and up to October 2007, most were weather-related (floods, droughts and storms).[158]

It is worth noting the scale of the devastation caused by some recent extreme weather events. It is not that these are "proof of climate change" (which is difficult to ascertain) but rather that they are proof of the vulnerability of cities and smaller settlements to extreme weather events – for instance the

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[150] United Nations (2006), op. cit.
[151] Cruz, Rex Victor and Hideo Harasawa, Murari Lal, Wu Shaohong with Yurji Anokhin, Batima Punsalmaa, Yasushi Honda, Mostafa Jafari, Congxian Li and Nguyen Huu Ninh (2007), Chapter 10: *Asia* in Parry, Canziani, Palutikof, van der Linden and Hanson (editors), op. cit. pages 469-506.
[152] Sources quoted in Cruz and Harasawa et al. (2007), op. cit: Kanai, S., T. Oki and A. Kashida (2004), "Changes in hourly precipitation at Tokyo from 1890 to 1999", *Journal of the Meteorological Society of Japan*, 82, pages 241–247; Manton, M.J., P.M. Della-Marta, M.R. Haylock et al. (2001): "Trends in extreme daily rainfall and temperature in Southeast Asia and the South Pacific, 1961–1998", *International Journal of Climatology*, 21, pages 269–284.
[153] Source quoted in Cruz and Harasawa et al. (2007), op. cit; Fan, D.D. and C.X. Li (2005): "Complexities of Chinese coast in response to climate change," *Advances in Climate Change Research* Vol. 1, Issue 3, page 111-114.
[154] Lal, M. (2001), "Tropical cyclones in a warmer world", *Current Science*, Vol. 80, No. 9, pages 1103–1104.
[155] Sources quoted in Cruz and Harasawa et al. (2007), op. cit: PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) (2001), *Documentation and Analysis of Impacts of and Responses to Extreme Climate Events*, Climatology & Agrometeorology Branch Technical Paper No. 2001–2, 55 pages; GCOS (2005), *GCOS Regional Action Plan for South and Southwest Asia*; Global Climate Observing System; ABI (Association of British Insurers) (2005), *Financial Risks of Climate Change, Summary Report*, 40 pages.
[156] This section draws directly from draft chapters of UN-Habitat (2007), *Enhancing Urban Safety and Security; Global Report on Human Settlements 2007*, Earthscan Publications, London, 480 pages.
[157] Hoeppe, Peter and Eugene N. Gurenko (2007), "Scientific and economic rationales for innovative climate insurance solutions" in Gurenko, Eugene N. (editor), *Climate Change and Insurance: Disaster Risk Financing in Developing Countries*, Earthscan Publications, London, pages 607-620.
[158] Borger, Julian (2007), "Climate change disaster is upon us, warns UN", *The Guardian*, October 5th, page 20, reporting on information released by the UN Offfice for the Coordination of Humanitarian Affairs.

devastation brought by Hurricane Mitch to Central America in 1998 (thousands killed, millions homeless, and billions of dollars worth of damage to already fragile economies),[159] or the devastation brought by flooding in and around Caracas in Venezuela in 1999 (around 30,000 people killed, and some 600,000 others seriously affected) or in and around various urban centres in Mozambique (Box 9). The Tsunami in late 2004, which killed over 200,000 people and destroyed the homes and livelihoods of millions was not related to climate change – but shows the vulnerability of so many urban (and rural) areas on the coast.[160]

A new United Nations Global Report[161] that focuses on disasters describes the long-term global trends in increasing numbers of disaster events, in people affected and made homeless by disasters and in the economic impacts of disasters, especially on the poor. It also notes how these show the weaknesses in the ability of governments and of the international community to protect their citizens from disaster risk and to respond to disaster. Reviewing all disaster events recorded on the University of Louvain emergency data (EM-DAT) database shows a steadily growing number of disasters, 1950 to 2006. A large proportion of the disasters recorded are in urban areas or affect urban areas. Other sources suggest that the rapid growth in the number of disasters is partly explained by the much-increased size of the urban population, including the prevalence of cities in hazard-prone areas.[162] Another example of the increasing impact of disasters comes from the expenditure patterns of the Asian Development Bank. During the 1980s, this Bank earmarked 6 per cent of loans for reconstruction, in the 1990s this rose to 20 per cent.[163]

Table 6 compares the global impact of different kinds of disasters between 1996 and 2005. Only events with over minimum thresholds of 10 deaths, 100 people affected or a call for international assistance or declaration of a state of emergency were included. Events such as droughts, famines and forest fires that are mostly situated in rural areas were not included in Table 6. Floods were the second most frequently reported disaster and affected the greatest number of people (1.3 billion people) and killed 391,610 people. Many of the transport disasters were caused by ships or boats sinking.

Table 6: Global extent and impacts of certain disasters by hazard type, total 1996–2005

	Number of events	Mortality	People affected (thousand)	Economic damage (US$ million, 2005 prices)
Avalanches/landslides	191	7,864	1,801	1,382
Earthquakes, tsunamis	297	391,610	41,562	113,181
Extreme temperatures	168	60,249	5,703	16,197
Floods	1,310	90,237	1,292,989	208,434
Volcanic eruptions	50	262	940	59
Windstorms	917	62,410	326,252	319,208
Industrial accidents	505	13,962	1,372	13,879
Miscellaneous accidents	461	15,757	400	2,541
Transport accidents	2,035	69,636	89	960

SOURCE: EM-DAT, CRED, University of Louvain, Belgium.

Box 9: The floods in Mozambique

The floods in 2000 in Mozambique killed at least 700 people, displaced 650,000 and affected 4.5 million. More than 70 per cent of all flood deaths were from urban areas, especially in the commercial hubs of the urban centres of Xai Xai and Chokwe. Large sections of the urban poor within Maputo, Xai-Xai and Chokwe suffered most as they lived in informal settlements in ravines, on slopes subject to landslides and in low lying areas. Many factors had contributed

[159] EM-DAT: The OFDA/CRED International Disaster Database (www.em-dat.net), Université Catholique de Louvain, Brussels, Belgium.
[160] Ibid.
[161] UN-Habitat 2007, op. cit.
[162] Kakhandiki, A. and H. Shah (1998), "Understanding time variation of risk. Crucial implications for megacities worldwide", *Applied Geography*, Vol. 18, No. 1, pages 47–53.
[163] Lavell (2001), op, cit.; German Committee for Disaster Reduction / German National Committee on Global Change Research (2002), *International Symposium on Disaster Reduction and Global Environmental Change*, 20–21 June 2002, Berlin.

to the risk – including deforestation and spontaneous occupation of plots and the building of roads in unsuitable areas The 16-year civil war also destroyed vital infrastructure while pushing people to urban areas (there were 3 million internally displaced people) and many settled on flood prone areas, with no knowledge or tradition of coping with flooding.

The flooding reached disastrous proportions when torrential rain brought on flooding in three rivers that flow within Maputo and Gaza provinces. One month later with systems already saturated, the heaviest rains for 50 years inundated the country for three days, exacerbating the flooding that had already begun in Maputo and Matola. The renewed flooding destroyed roads and bridges, isolating areas within these two cities. As flooding continued, cyclone Eline hit Inhambane and Sofala provinces, increasing the water in the Limpopo river and creating waves up to 3 metres high and flooding cities of Chokwe and Xai-Xai.

This was also a very severe glow to economic growth for one of the world's poorest nations. Maputo is the hub of the nation's industrial production while Matola is a major industrial centre and primary port and Xai-Xai is a provincial capital and important for fishing and tourism.

SOURCE: UN-Habitat (2007), *Enhancing Urban Safety and Security; Global Report on Human Settlements 2007*, Earthscan Publications, London, 480 pages.

Looking only at the incidence of "large" disasters (in both rural and urban areas) and their impacts, by region from 1996 to 2005:

In Africa, there were 290 flood-disasters with 8,183 people killed, 23 million people affected and economic losses of $1.9 billion. Flood disasters were the most frequent "natural" disasters and also the ones that produced the highest mortality. They were second to earthquakes/tsunamis for the scale of economic losses and second to drought/famine in terms of people affected. Windstorms were less numerous (74) but they killed 1,535 people and affected 3.9 million over this period.

In the Americas, there were 281 flood-disasters; they killed 38,028 people, affected 9.5 million and caused economic losses of $27.9 billion. Windstorms were more numerous (321) and they killed 28,110 people and affected 25.3 million; they also much the largest economic losses ($234.7 billion). Climate variability has become a major development issue for Latin America. The El Niño Southern Oscillation (ENSO) and hurricanes are key sources of climate events, frequently coupled with other environmental impacts on urban areas. For example, two extremely intense episodes of El Niño (1982–83 and 1997–98), together with land-use changes, resulted in floods, droughts, landslides and other disasters killing people and affecting the population, infrastructure and economic activities of such urban areas as Havana, Quito, the Panama Canal watershed and Asuncion.[164] The incidence of disasters related to weather has increased by 2.4 times during 1970–2005, and it is expected to increase in future.[165]

In Asia, there were 472 flood-disasters with 42,570 people killed and 1.3 billion people affected. These were the most common "natural" disasters and also those with the most people affected and the highest economic losses ($129 billion) – although deaths from earthquakes/tsunamis (364,651 deaths) and from droughts/famines (216,923 deaths) were much higher. Obviously, the mortality from earthquakes/tsunamis was much influenced by the 2004 Indian Ocean Tsunami with around 230,000 deaths. Windstorm disasters were the second most frequent "natural" disaster, with 31,900 deaths, 289 million people affected and $62 billion in economic losses.

The IPCC Working Group II chapter on settlements noted some estimates for the impacts of extreme weather events on nations' GDPs, which include a 4–6 per cent loss for Mozambique for the flooding in 2000,[166] a 3 per cent loss for central America from El Niño and a 7 per cent loss for Honduras from Hurricane Mitch. These national aggregations can obscure the fact that for specific regions or locales, the impact can be greater – ranging from more than 10 per cent of gross domestic product and gross capital formation in larger, more developed and more diversified impacted regions to more than 50 per cent in

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[164] Glanz, Michael (editor) (2001), *Once Burned, Twice Shy? Lessons Learned from the 1997–98 El Niño*, United Nations University, Tokyo.
[165] Magrin et al. (2007), op. cit, page 6.
[166] Cairncross, S. and M.J.C. Alvarinho (forthcoming), "The Mozambique floods of 2000: health impact and response" in Few, R. (editor), *Flooding and Health*, Earthscan, London (in press).

less developed, less diversified, more natural-resource-dependent regions.[167]

It is possible to envisage a trend in new investments by larger companies and corporations away from cities and city-sites most at risk from floods, storms and sea-level rise that will hardly affect their operations. They have long been adept at shifting production to locations where profits are maximized, and it is easy for them to factor in risks from climate change. But it is difficult to conceive of how many of the largest successful coastal cities most at risk from storms and sea-level rise will manage. As described above, cities such as Mumbai, Shanghai and Dhaka are very vulnerable to sea-level rise. All of them are very large (each having well over 10 million inhabitants), have had considerable economic success in the last few decades, have great importance to their nations' economies and cultures, and concentrate very large investments and economic interests. Most residents and smaller businesses have much-reduced possibilities for moving – and face far more serious losses if the value of their properties declines. Meanwhile, the movement of larger companies and corporations out of large cities also threatens the cities' economic bases and the livelihoods of those who worked for these companies or provided goods and services to them or their workforces.

Urban poverty and risk

At least 900 million urban dwellers live in poverty in low- and middle-income nations.[168] There are no precise figures because many aspects of poverty are not measured. For instance, in most nations, no data are available on two of the most important indicators for assessing the scale of poverty: household incomes and the cost of non-food necessities. Most poor urban households derive most or all of their income from work in the informal economy for which there are no data on incomes.

But there is strong evidence on the scale of urban poverty from other sources – for instance from data on the number of urban dwellers with inadequate nutrition levels and the numbers living in housing of very poor quality (with particular problems in relation to poor-quality structures, overcrowding, insecure tenure and inadequate provision for water, sanitation and drainage). One other indication of the scale of urban poverty is the number of people living in illegal settlements because they cannot afford to buy, build or rent legal accommodation; in many cities, 30–60 per cent of the entire population lives in settlements that were developed illegally.[169]

Statistics on infant and child mortality rates for urban populations show that these are often 5–20 times what they should be, if their families had adequate incomes, reasonable-quality housing and good health care.[170] There are also many case studies focusing on low-income urban populations that show very large health burdens from diseases that should be easily prevented or cured – for instance diarrhoeal diseases, intestinal parasites, TB and acute respiratory infections. Table 7 summarizes the estimates for the scale of different aspects of urban poverty.

The number of urban dwellers who are "poor" is always much influenced by how poverty is defined and measured. If poverty is considered to encompass all those who have difficulties affording basic necessities and who are either homeless or live in poor-quality, overcrowded and often illegal accommodation, then in 2000, at least 900 million urban dwellers were poor,[171] and the numbers are likely to have risen significantly since then (the urban population in low- and middle-income nations has grown by around 300 million since 2000).[172]

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[167] Zapata-Marti, R. (2004), The 2004 Hurricanes in the Caribbean and the Tsunami In the Indian Ocean: Lessons and Policy Challenges for Development and Disaster Reduction, LC/MEX/L.672, Estudios y perspectivas series, 35, 62 pages.
[168] UN-Habitat (2003), *The Challenge of Slums*, op. cit.
[169] Hardoy and Satterthwaite 1989 op. cit.; UNCHS (1996), *An Urbanizing World: Global Report on Human Settlements, 1996*, Oxford University Press, Oxford and New York; Hardoy, Mitlin and Satterthwaite (2001), op. cit.
[170] Satterthwaite (2007), "In pursuit of a healthy urban environment", op. cit.
[171] UN-Habitat (2003), *The Challenge of Slums*, op. cit
[172] United Nations (2006), op. cit.

Table 7: Estimates for the scale of urban poverty in low- and middle-income nations

Type of poverty	Numbers of urban dwellers affected	Notes
Inadequate income in relation to the cost of basic needs	750–1,100 million	No accurate figures are available on this, and the total varies depending on the criteria used to set the poverty line (the "income-level" required for "basic needs").
Inadequate or no provision for safe, sufficient water and sanitation	More than 680 million for water and 850 million or more for sanitation	These estimates are drawn from a recent, detailed global UN review of individual city/urban studies.[173]
Undernutrition	150–200 million	In many Asian and sub-Saharan African nations, 25–40% of urban children are underweight.[174]
Living in housing that is overcrowded, insecure and/or of poor quality	924 million	Based on a recent global UN review of the proportion of people living in "slums".[175]
Homelessness (i.e. living on the street or sleeping in open or public places)	c.100 million	UN estimate.[176] There are also large numbers of people living on temporary sites (for instance construction workers and often their families living on site) that are close to homeless.

Of course, within these hundreds of millions of people suffering urban poverty, there is considerable variation – from those who are destitute and suffering from acute malnutrition to those who are managing or at least largely avoiding extreme deprivation, as long as there is no crisis (for instance a drop in their income, a rise in food prices or in other major costs such as rent for housing or an income-earner being sick or injured). Table 8 illustrates this.

Table 8: Different degrees of poverty in urban areas

Aspects of poverty	Degrees of poverty			
	Destitution	**Extreme poverty**	**Poverty**	**At risk of being poor**
Income	Income below the cost of a minimum food basket	Income just above the cost of a minimum food basket but far too low to allow other necessities to be afforded	Income below a realistic poverty line* but enough to allow significant expenditure on non-food essentials	Income just above a realistic poverty line*
Housing with access to infrastructure and services	Homeless or living in a very poor-quality shack with no provision that is no-cost – or close to no-cost	Very little to spend on housing – often renting a room in tenement or illegal or informal settlement shared with many others	More accommodation options – e.g. slightly more spacious, better-quality rental housing or capacity to self-build a house if cheap or free land is available. The extent and quality of low-cost housing options is much influenced by government land, infrastructure and services policies and investments	
Assets	Typically none or very little (although membership of a community-based savings group may provide access to small amounts of credit for emergencies)		Often some capacity to save, especially within well-managed savings and credit schemes; housing the most valuable asset for those who manage to "get their own home" even if it is illegal	
Vulnerability	Extreme vulnerability to food-price rises, loss of income or illness or injury. Often also to discrimination and unfair practices (from employers, landlords, civil servants, politicians and the law)		Similar kinds of vulnerability to those faced by people facing destitution or extreme poverty, although usually less severe; often vulnerability to running up serious debt burdens; always vulnerability to illness/injury and its direct and indirect impacts on income	

[173] UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.
[174] See later section on this.
[175] UN-Habitat (2003), *The Challenge of Slums*, op. cit
[176] UNCHS (1996), op. cit.

* A realistic income-based poverty line would be one that was calculated based on real costs in each city and which took into account the cost of non-food essentials (for instance rent, transport to and from work and essential services, water, sanitation, health care and keeping children at school) as well as the cost of an adequate diet. Most poverty lines in low- and middle-income nations make no such provisions, which is why the scale and depth of urban poverty is so consistently under-estimated.

SOURCE: Satterthwaite, David (2004), *The Under-estimation of Urban Poverty in Low and Middle-Income Nations*, IIED Working Paper 14 on Poverty Reduction in Urban Areas, IIED, London, 69 pages.

Effects of increased climate variability and change on the urban poor

As described above, the main impacts of climate change on cities, at least in the next few decades, are likely to be increased levels of risk from existing hazards. For poorer groups, some of the impacts are very direct – for instance, more frequent and more hazardous floods. Some are less direct – for instance, reduced availabilities of freshwater supplies for whole cities that reduce supplies available to poorer groups (or that increase prices). Some are very indirect – for instance, as the direct or indirect impacts of climate-change-related weather events increase food prices or damage poorer households' asset bases or disrupt their incomes. In considering the vulnerability of the poor to increased climate variability and change, there is a need to consider how this might negatively affect their income (which may come from a variety of sources), their asset base, the prices they pay for necessities, their homes and the infrastructure and services on which they depend.

It is well known and well documented that, in most cities, the urban poor live in the riskiest urban environments – for instance on floodplains or other areas at high risk of flooding or unstable slopes.[177] These are also usually the sites most at risk from climate change, as discussed above. In addition, in most cities, the urban poor also have problematic relationships with local government – which is meant to be the institution that acts to reduce these risks. In part, this is because most of the urban poor live in informal settlements (including many on land occupied illegally) and work within the informal economy (and thus not within official rules and regulations). In part, it is because of the "anti-poor" attitudes among government officials and elites, so often based on misconceptions. For instance, is may be assumed that people are unemployed when they work long hours within the informal economy, or that they are recent migrants when they have long worked and lived within the urban centre (or, in many cities, may well have been born there), or that migrants would have been better off if they had not moved (when so many migration studies show that migration flows are logical responses to changing patterns of economic opportunity). One added vulnerability faced by large sections of the urban poor is that governments may clear them off land sites deemed to be vulnerable to (for instance) floods, with very inadequate or no provision for finding alternative accommodation that meets their needs.

The IPCC notes the particular problems of densely populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence. It also notes how adaptation for coasts will be more challenging in low- and middle-income nations, due to constraints on adaptive capacity. In general, the people most at risk from climate change are those living in affected areas who are:

- least able to avoid the direct or indirect impacts (e.g. by having good-quality homes and drainage systems that prevent flooding, by moving to places with less risk or by changing jobs if climate-change threatens their livelihoods);
- likely to be most affected (for instance infants and older groups who are less able to cope with heatwaves);
- least able to cope with the illness, injury, premature death or loss of income, livelihood or assets caused by the kinds of impacts.

Poorer groups get hit hardest by this combination of greater exposure to hazards (e.g. a high proportion living in makeshift housing on unsafe sites), lack of hazard-removing infrastructure and less capacity to

[177] IIED's Human Settlements Group has been documenting this since the early 1980s. See, for instance, Hardoy, Jorge E. and David Satterthwaite (1984), "Third World cities and the environment of poverty", *Geoforum*, Vol. 15, No. 3, pages 307–337. For a more detailed and up-to-date review, see Hardoy, Mitlin and Satterthwaite (2001), op. cit.

cope (e.g. lack of assets and insurance), less adaptive capacity, less state provision to help them cope, and less legal protection or protection from insurance. Low-income groups also have far less scope to move to less dangerous sites; indeed, the more dangerous sites are often the only sites where lower-income groups can find housing they can afford or can build their own homes.

Wealth allows individuals and households to reduce risks – for instance by having safer housing, choosing safer jobs or locations to live in, having assets that can be called on in emergencies and protecting their wealth by insuring assets that are at risk. Although it should be through good governance that provision for risk reduction is ensured for the whole city population and disparities in risk between income-groups reduced, wealthier groups often have more influence on public expenditures – and it has long been common for middle- and upper-income groups to be the main beneficiaries of government investment in infrastructure and services. If government does not provide these, higher-income groups have the resources to solve this problem themselves – for instance by developing their own provisions for water, sanitation and electricity, or moving to private developments which provide these. Indeed reconstruction post-disaster can offer real opportunities for private gain and it has been argued that this is one reason why disasters are managed through post-disaster reconstruction rather than pre-disaster risk management that would favour more socially progressive policies to reduce the vulnerability of the poor and enhance city-wide critical infrastructure such as drainage and sanitation.

The quality of government – both at national level and, as crucially, at local (district or municipal) level – influences the levels of risk from climate change facing those with limited incomes or assets in several ways:

- quality of provision for infrastructure for all areas (which should limit risks of flooding for the whole city area, not just for the wealthier areas);
- quality of provision for disaster-preparedness (including warnings, measures taken to limit damage and, if needed, good provision to help people move to safer areas quickly);
- quality of planning for and coordinating disaster-response (for instance rescue services and appropriate emergency and health care services) and reconstruction (to help those who have lost their homes and livelihoods) which should aim to improve resilience, but seldom achieves this;
- extent to which poorer groups can buy, build or rent "safe" housing in "safe" sites;
- degree to which local government creates an enabling environment for local civil-society action to contribute towards addressing the practical aims identified above.

There are different vulnerabilities to the health impacts of heat- and cold-waves, on the one hand, and air pollution within urban areas on the other. Local factors, such as climate, topography, heat-island magnitude, income, access to health services and the proportion of elderly people, are important in determining the underlying temperature–mortality relationship in a population.[178] Winter mortality and morbidity in high altitude and colder cities depend on the quality of households' home-heating, the health of the populations, and the conditions of prevention and treatment of winter infections.[179]

In India, the critical populations and elements most at risk in a typical city are:

- slum, squatter and migrant populations resident in traditional and informal settlements, which are often located in the most vulnerable locations;
- industrial and informal service-sector workers, whose occupations place them at significant risk, which is then accentuated by additional stressors such as climate change;
- buildings, especially traditional and informal housing stock, that are especially vulnerable to wind, water and geological hazards;
- industrial units, their in-house infrastructure, plant, machinery and raw materials;
- lifeline public and private infrastructure, which includes: roads, bridges, railways, ports, airports and other transportation systems; water, sewage and gas pipelines; drainage, flood and coastal defence systems; power and telecommunications infrastructure and critical social infrastructure such as hospitals, schools, fire-service, police-station and first responder's infrastructure;
- the natural environment, especially including wetlands, riverine, estuarine and coastal

[178] Curriero et al. (2002), op. cit.
[179] Carson et al. (2006), op. cit.

ecosystems, surface and groundwater systems.[180]

Who is most at risk? Differentials by location, income-level, age and gender

Table 8 illustrates the range in degrees of poverty – which will influence vulnerability levels to almost all hazards. Thus, there is considerable variation within "low-income" urban dwellers in regard to their vulnerability to climate change, both in terms of the hazards to which they are exposed and in terms of their capacity to cope and adapt. For instance, there are large variations between the settlements in which they live in the quality of their homes, in the extent of provision for infrastructure and in the risks facing their settlements from flooding or landslides. Within informal settlements, tenants with low-incomes are often particularly at risk, especially where the landlord does not live on the premises. Absent landlords remove the link between those responsible for the quality of the housing and those who are at risk from it – and they usually operate with no regulation to enforce health and safety standards. The scale and exploitative nature of large-scale landlordism in informal settlements is well documented in Nairobi – but common in many other cities.[181] Tenants have less interest in risk-reduction, especially if they regard their stay as temporary. It is difficult to engage residents with short-term outlooks in addressing longer-term concerns. For instance, residents will have little interest in contributing to infrastructure improvements if they are seasonal or temporary migrants.

There are also large variations in the asset bases that different low-income individuals or households can call on to help cope with emergencies and in the quality and extent of safety nets on which they can draw. There are obvious variations in the speed with which different groups (infants and younger children and the adults caring for them, the disabled, older people) can move in response to impending risks (and variations in having safe places to move to) and in the possibilities of them being reached by appropriate public information on what to do.

Within low-income populations, women often have particular vulnerabilities as a result of gender-related inequalities – because of the tasks they undertake or the discrimination they face in accessing jobs (which also means lower or less stable incomes), resources (including property titles) or services. Gender inequalities that exist prior to a disaster manifest themselves in many ways afterwards – not only in the differentials in impacts but also in the resources and services available to support recovery and reconstruction. When homes and neighbourhoods are destroyed or damaged, this obviously affects those who provide infants and children with care – which is generally women. This often affects women's incomes more than men's as they undertake income-earning activities from home and so lose the income when the house or the equipment they used is lost. Where women take most responsibility for children, they are constrained in their capacity to move rapidly – for instance to avoid floodwaters. Women generally spend more time in and around the home because they have most of the child-rearing and household-management tasks and/or work there; in some societies, women are constrained by social norms from being able to leave the home and have particular difficulties accessing any post-disaster services. These all act to increase risks to women, if their homes and settlements are at particular risk from climate-shocks. This helps to explain why many climate-disasters have mortality rates among women that are significantly higher than for men.

For populations that have to move – either temporarily or permanently – it is rare for women's needs and priorities to be addressed or even considered in the temporary or resettlement accommodation; the same is true for children and youth. There are also case studies showing the particular disadvantages and risks that women face after disasters – and, within this, instances of the particular problems faced by women-headed households and widows.[182]

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[180] Revi (2007), op. cit.

[181] Amis, Philip (1984), "Squatters or tenants: the commercialization of unauthorized housing in Nairobi", *World Development*, Vol. 12, No. 1, pages 87–96; Yapi-Diahou, Alphonse (1995), "The informal housing sector of the metropolis of Abidjan, Ivory Coast", *Environment and Urbanization*, Vol. 7, No. 2, October, pages 11–29; UNCHS (1996), op. cit.

[182] See the summaries drawn from many case studies in Enarson, Elaine (2004), *Gender Matters: Talking Points on Gender Equality and Disaster Risk Reduction*, 22 pages, available from the Gender and Disaster Network, http://www.gdnonline.org/wot_practical.htm.

Disaster events often impact women disproportionately, endangering the personal safety of girls and women, as well as women's livelihoods, assets, income sources, health and future opportunities. Women's and girls' needs often get little attention after disasters, including health needs and protection against sexual and domestic violence.[183] Restoring the base for women's livelihoods often gets less attention than men's – and it is common for women to take on most of the child-rearing and domestic responsibilities, even as these are more onerous and time consuming – for instance greater difficulties getting food, fuel and water, among other domestic responsibilities. Meanwhile, "women struggle in the fast-closing post-disaster 'window of opportunity' for personal security, land rights, secure housing, employment, job training, decision-making power, mobility, autonomy, and a voice in the reconstruction process."[184]

Enarson and Meyreles highlight another key issue - the neglect of women's individual and collective capacities for recovery and reconstruction – for instance as community leaders, neighbourhood networkers, producers, gardeners, rainwater harvesters, monitors of flood prone rivers……. They also note the need to draw on women's resources, skills, capacities, assets, experiences and hard-won knowledge about how to make life safer and live with risk. There are many examples of the benefits for women and the wider public from supporting women's involvement in reconstruction – and in supporting them in rebuilding their livelihoods.[185]

Children as a group will be affected by both extreme events and longer term climate-change in particular ways, and generally in more extreme ways, than the population as a whole.[186] This is because of their greater physiological and psychosocial vulnerability to a range of associated stresses – but also because of the long-term developmental implications of these vulnerabilities. Disruptions to water supplies and sanitation systems for instance, are far more likely to result in diarrhoeal illness for infants and young children than for other age groups, and repeated episodes can have long-term implications for physical growth and even cognitive functioning. Young children also have less capacity to cope with heat stress, deteriorations in urban air quality, threats to food supplies and the increases in certain vector-borne diseases associated with climate change. Obviously, low-income groups have more limited capacities to cope with these. Almost all of the disproportionate implications for children are exacerbated by poverty and by the difficult choices that must be made by low-income households as they adapt to more challenging conditions. Many of the well-documented pathways between poverty and poor developmental outcomes for children are intensified by the added pressures of climate change.

There is not enough hard knowledge about the implications of climate change for children to present a comprehensive picture. Even where the more general impacts of climate change have been estimated, the figures are not disaggregated to reflect the specific implications for children. But it is possible to extrapolate from existing knowledge in a number of related areas. Work on environmental health in urban areas, on disaster responses, on household coping strategies, on the range of effects for children of urban poverty, on the resilience of children and the beneficial effects of their participation in various efforts, all contribute to a broad sense of the potential implications – of both disasters and responses to them, and of more gradual change and the adaptations likely to be made at various levels.

It is also obvious that infants and young children living in poor-quality housing in informal settlements face a range of particular risks from extreme weather events – in terms of both direct risks of the inadequacies in responding to children's needs and priorities, during and after any disaster. But this is part of a wider problem within cities and city neighbourhoods in failing to understand and address the priorities of boys and girls of different age groups.[187]

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[183] Enarson, Elaine and Lourdes Meyreles (no date), *International Perspectives on Gender and Disaster: Differences and Possibilities*, mimeo, 26 pages; available from the web-site of the Disaster and Social Crisis Research Network http://www.erc.gr/English/d&scrn/murcia-papers/session2/Enarson_Meyreles_II_Original.pdf

[184] Enarson and Meyreles (no date), op. cit.

[185] Enarson (2004), op. cit.

[186] This text draws direct from a background paper prepared by Sheridan Bartlett: "The Impacts of Climate Change for Children", published in *Children, Youth Environments,* http://www.colorado.edu/journals/cye/

[187] See for instance Bartlett, Sheridan et al. (1999), *Cities for Children: Children's Rights, Poverty and Urban Management*, Earthscan, London, 305 pages.

All the particular vulnerabilities of women in the face of disaster have, in turn, implications for the children in their care. There is a growing literature on the inadequacies in provision for the needs of children and youth and their care-givers (mostly women) in disaster-preparedness and in post-disaster settlements that has relevance for climate-change adaptation. This includes discussions of the importance of involving children and youth in development issues and of their very considerable individual and group competencies and capacities.

There are also the particular vulnerabilities that many older men and women face that need consideration – for instance, the greater risks that heat stress poses or limitations in the capacity to move rapidly away from rising floodwaters. The vulnerability of older people may also be linked to their isolation. As adaptation plans and processes get more locally rooted and more influenced by low-income groups, so the particular vulnerabilities of different groups within the population relating to income-levels, gender and generation should become more apparent.

Each city will have particular groups within its population for whom even relatively "minor" direct or indirect impacts of climate change will be particularly problematic – because they are so vulnerable to any added stress or shock. These include groups that are already facing serious health problems – for instance those with HIV/AIDS and/or TB who have no chance of appropriate treatment, those with serious physical disabilities, orphans and child-headed households and those with no housing (including construction workers and children of the street). Their vulnerability is usually related both to higher levels of risk and to very limited coping capacity.

How are the urban poor presently adapting?

"When we see very dark clouds up the hills, we expect heavy rains to come. So we get ourselves prepared by transferring our valuable things on our very high beds which are reached by climbing ladders. Also children who sleep on the floor are transferred to the high beds." Mrs Fatu Turay, Kroo Bay community, Freetown, Sierra Leone.[188]

Poorer groups in urban areas spend most of their lives adapting to changing conditions – changing economic opportunities, changing political circumstances and changing risks to their homes. But as discussed in detail above, their survival needs and economic priorities often conflict with risk reduction. Box 10 presents a case study in Indore (India): the inhabitants of a low-income settlement at high risk of flooding had developed their own temporary and permanent adaptations to flooding and were unwilling to move to safer sites because these would not be so well located in regard to income-earning opportunities.[189] This does not mean that low- income households living on dangerous sites will not move but it does mean that measures to relocate them must fully involve such households in choosing alternative locations and setting the terms under which the new sites are acquired and provided with infrastructure and services.

A case study in El Salvador showed the difficulties of getting appropriate risk-reduction action for lower-income groups. Drawing on interviews and discussions with people living in 15 disaster-prone "slum" communities and with local organizations, these difficulties became apparent. Low-income households recognized that flooding and landslides were the most serious risks to their lives and livelihoods, although earthquakes and windstorms, lack of job opportunities and water provision and insecurity due to violent juvenile crimes were also highlighted. These households invested in risk reduction and on average spent 9 per cent of their incomes doing so. Many took measures to lower risks – for instance diversifying their livelihoods or having assets that were easily sold if a disaster occurred. Remittances from family members working abroad were important for many families, especially in providing support for recovery after a disaster. But a complex range of issues limited their effectiveness – for instance the individualistic nature of households' investments, the lack of representative community organizations

[188] Douglas, Ian, Kurshid Alam, MaryAnne Maghenda, Yasmin Mcdonnell, Louise McLean and Jack Campbell (2008), "Unjust waters: climate change, flooding and the urban poor in Africa", *Environment and Urbanization*, Vol. 20, No. 1.

[189] Stephens, Carolyn, Rajesh Patnaik and Simon Lewin (1996), *This is My Beautiful Home: Risk Perceptions towards Flooding and Environment in Low-income Urban Communities: A Case Study in Indore, India*, London School of Hygiene and Tropical Medicine, London, 51 pages.

through which to design and implement settlement-wide measures and the lack of support from government agencies (most residents viewed local and national governments as unhelpful or even as a hindrance to their efforts). Meanwhile, most of the institutions that supported social housing and housing finance initiatives – local and international NGOs, and government agencies – did not consider risk-reduction. Although their programmes usually supported safer houses, which reduced risks in the event of a disaster, they did nothing to support insurance or to enhance family or community capacity for recovery. There was a need to support a capacity to work collectively so each household's individual efforts contributed to community-wide risk reduction, and also for trustworthy local governments and professional advice on the cheapest ways to secure and protect homes.[190]

Box 10: Low-income households' adaptation to flooding in Indore, India

In many low-income communities in Indore, flooding is perceived as a natural, seasonal event, and households take steps to limit the damage it does. Those who live on land sites adjacent to small rivers that are also key storm drains are particularly at risk. But these sites have the advantage of a central city location. They have economic advantages because they are close to jobs or to markets for the goods these households produce or collect (many earn a living collecting waste). The land is cheap and because it is in public ownership residents are less likely to get evicted. These sites have social advantages because they are close to health services, schools, electricity and water. Most inhabitants have strong family, kinship and community ties with other inhabitants. Some residents have noted that the sites are considered safer for children because the narrow streets make them inaccessible to motor vehicles.

Households and small enterprises have made both temporary and permanent adaptations to flooding. These include raising plinth levels and paving courtyards, using landfill, using materials which resist flooding, choosing furniture that is less likely to be washed away and ensuring that shelving and electric wiring are high up the walls, above expected water levels. Roofing may not be attached to a house so it can be quickly removed if the structure is in danger of being swept away. Many households also have suitcases ready, so valuables can be carried away.

Residents have also developed flood-prediction and protection systems, and contingency plans for evacuating persons and possessions. In one settlement (Shekha Nagar), residents' first response to the threat of severe floods is to move the elderly, children and animals to higher ground. Then they move electrical goods such as televisions and radios. Then other lighter valuables and cooking utensils are moved, with clothes being moved last as these are more easily replaced and not damaged by flooding. The more established residents have also learnt how to use the state system of compensation for flood damage, and this can provide a perverse incentive for residents to build houses in the most vulnerable and dangerous areas.

SOURCE: Stephens, Carolyn, Rajesh Patnaik and Simon Lewin (1996) *This is My Beautiful Home: Risk Perceptions towards Flooding and Environment in Low-income Urban Communities: A Case Study in Indore, India*, London School of Hygiene and Tropical Medicine, London, 51 pages.

Box 11: Adaptation activities to cope with floods in African cities

ActionAid has held discussions with the residents of poor communities in cities including Accra, Kampala, Lagos, Maputo and Nairobi on what flooding problems they face, why these occur, how members of the community adjust to them, who is responsible for reducing flood risk and what action the community itself could take. Residents in each of the cities suggested that flooding had become more frequent and many suggested that it had become less predictable. In discussing what underpinned flooding, residents emphasized the lack of adequate drainage, poor management of existing drainage, unplanned and unregulated urban development, lack of attention to the problem by government and changes in weather patterns.

In Nairobi's informal settlements (where around half the population lives), responses to flooding include: bailing water out of houses to prevent damage to belongings; placing children initially on tables and later removing them to nearby unaffected dwellings; digging trenches around houses before and during floods; constructing temporary dykes or trenches to divert water away from the house; securing structures with waterproof recycled materials; relocating to the highest parts of the dwelling that residents think are secure; or using sandbags to prevent the ingress of water.

Residents in Alajo in Accra noted, "When the rain and the floods come, women and children suffer. You can be locked up for up to two days with the flood. Sometimes we take our children out from the room to the rooftop. Then people bring boats to evacuate others." People dealt with the floods of June and July 2006 in a variety of ways, such

[190] Wamsler, Christine (2007), "Bridging the gaps: stakeholder-based strategies for risk reduction and financing for the urban poor", *Environment and Urbanization*, Vol. 19, No. 1, pages 115–142.

as: using blocks, stones and furniture to create high places on which to put their most critical valuables during floods; putting goods on top of wardrobes and in the small spaces between ceilings and roofs; sharing such high places with others who have no similar “safe” sites; or temporarily moving away from the area to stay with friends and family.

Similar strategies were adopted by individuals in Kampala. In addition, some residents undertook collective work to open up drainage channels; others temporarily moved to lodges and public places like mosques and churches until the water level receded, or constructed barriers to water entry at the doorsteps and outlets at the rear of their houses so any water entering their homes flowed out quickly.

In Lagos, both those living in informal settlements and representatives of local government believe that clearing the drainage channel running through Iwaya/Makoko would prevent the pooling of water from other parts of the city. Standard drainage facilities along major streets within Iwaya/Makoko would help to solve the flood problem. The inhabitants have also suggested using sand to raise the entire area to a higher level. One resident commented “There has not been assistance from anyone. Neighbours cannot assist because everybody is poor and vulnerable. I am planning to quit this place because it is horrible living here. Government should sand fill this place.”

In all the cities, resident responses were typically ad-hoc, individual short-term efforts to survive (for instance to sleep on high tables or wardrobes and move family members to safer sites), or to protect property (for instance making barriers to water entry at the door, digging trenches to steer water away from the door, making outlets at the rear of the house so water coming out flowed out quickly). Spontaneous community action to unblock drainage channels is relatively rare. There was no evidence of coordinated action for emergency shelter or rapid response to flooding in any of these cities.

SOURCE: Source: Douglas, I. and K. Alam (2006) *Climate Change, Urban Flooding and the Rights of the Urban Poor in Africa: Key Findings from Six African Cities,* ActionAid International, London. Available at: http://www.actionaid.org.uk/doc_lib/urban_flooding_africa_report.pdf. See also Douglas, Ian, Kurshid Alam, MaryAnne Maghenda, Yasmin Mcdonnell, Louise McLean and Jack Campbell (2008), "Unjust waters: climate change, flooding and the urban poor in Africa", *Environment and Urbanization*, Vol. 20, No. 1.

Conclusions

The last two decades have brought lots of lesson-learning from disasters, lots of discussion on the needed alignment of development and disaster-prevention/preparedness/response, good methodologies for identifying and assessing risks and good evidence for cost-savings from advance preparedness for potential disaster events. There is a need to understand why these are not being more effective in influencing policy and action.

Why don’t governments act to reduce risk from extreme weather events?

- There is a conscious decision by governments to ignore the settlements most at risk, and a view that governments “cannot” provide infrastructure to illegal settlements.
- An inability to perceive the problem (national agencies responsible for disasters having a perception of disasters as being rural and related to famine and drought, while urban authorities do not see preventing disasters as their responsibility).
- A lack of awareness of the value of the assets lost by affected poor populations (and of their importance to city economies).
- No local data to demonstrate the extent of the problem (often related to institutional inadequacies).
- An inability to act, or an absence of structures to address the problem (for instance, local government being responsible for providing the infrastructure that should greatly reduce risks but having a very small proportion of total government funding).
- An absence of political channels to allow vulnerable communities to demand action on reducing unacceptable levels of risk.

In addition to these reasons, a critical constraining factor is found in the international and national funding streams that provide a perverse incentive. Money is readily available for post-disaster relief and reconstruction, but not for risk reduction and development. For example in Guyana, international finance for the maintenance of sea-walls has been hard to come by and funding for incremental improvements is similarly difficult. But following breaches in the sea-wall, funding is made available.

Why don't low-income communities act to reduce risk?

- Dangerous sites are often the only places they can live and still access livelihood opportunities.
- The infrastructure needed to reduce risks is expensive; in illegal settlements, the inhabitants' unwillingness to invest in infrastructure is because of the risk of being evicted.
- Failure to perceive the seriousness of disaster risk until a disaster event occurs.
- Disasters (e.g. flooding) occur so regularly that communities become accustomed to living with risk rather than seeking to limit their scale and impact.
- Constraints on being able to act effectively (e.g. difficulty in getting agreement on action within their settlement or in raising the funds needed to act effectively; or too many other pressures).
- The difficulties in getting support from government (often related to weak local governments that cannot do much anyway, or unaccountable and undemocratic governments on which it is difficult to apply pressure for support).
- National and local political structures that create incoherent and poorly coordinated funding systems, from which it is difficult to get funding for coordinated, long-term programmes.

Even after disasters, risk reduction is often ineffective. In reconstruction, external support is often readily available but with constraints. Humanitarian agencies do not have developmental skills or approaches that support and encourage local participation, leading to ineffective and inappropriate investments. Funding budgets from donors often have to be spent in a short time period, usually within 12 months, and are not available to support longer-term development processes.

Why don't international agencies act to reduce risk?

- Most international agencies deliberately avoid urban initiatives, a decision usually justified by questionable assumptions about the relative scales of urban and rural poverty.[191]
- Many international agencies leave disaster management to other specialist disaster agencies – or have weak links between their disaster departments and development departments (e.g. with development and disaster budgets kept separate).
- Acting to reduce risk often requires actions undertaken in collaboration with many different agencies. Funders like simple, discrete projects, so it is difficult to get funding for risk-reduction projects which are cross-disciplinary, involving many agencies and integrating many components (often referred to disparagingly by international agencies as "Christmas tree projects" because they have so many different components).
- Effective risk-reduction strategies have to be locally determined but official development assistance agencies work primarily through national governments; such strategies often involve long-term processes whose effectiveness may be hard to demonstrate. For instance, it is difficult to prove how many lives have been saved or livelihoods protected by risk-reduction measures when an extreme weather event happens.
- Each international agency has its own programmes, criteria for allocating funding, and project cycles (which helps to explain the poor integration between them).[192]

IV. IDENTIFYING INNOVATIVE LOCAL/CITY ADAPTATIONS TO CLIMATE CHANGE

Start with what you have, build on what you know

For most environmental hazards, local governments can act to remove or lessen them. For climate-change, they cannot.[193]

In the literature on climate change, adaptive capacity is the *potential* of a system or population to modify its features or behaviour to cope better with existing and anticipated stresses.[194] So adaptation is about

[191] Satterthwaite (2001), op. cit.; Tannerfeldt and Ljung (2006), op. cit.

[192] The Paris accord is meant to address this but it does nothing to encourage international funding agencies' engagement with or support for local governments. See Satterthwaite, David (2005), "Meeting the MDGs in urban areas; the forgotten role of local organizations", *Journal of International Affairs*, Vol. 58, No. 2, pages 87–112; Crespin (2006), op. cit.

[193] Of course, they can take actions to reduce greenhouse gas emissions but this represents a small contribution to reducing future impacts globally; it does nothing to reduce climate-change related risks in their jurisdiction.

enhancing resilience or reducing people's vulnerabilities to observed or expected changes in climate.[195] Development should increase adaptive capacity and reduce the vulnerability of low-income groups. Adaptive capacity will influence adaptation (the *actual* adjustments made) although high adaptive capacity does not necessary translate into measures that reduce vulnerability.

In terms of who has to adapt, discussions for urban areas highlight that this includes governments, enterprises and households. Organizations need to adapt their own behaviour, goals and practices and support progressive and proactive adaptation among other actors. Government agencies, and especially local government, are the most important for shaping the operating environment that influences the capacity for households and businesses to build adaptive capacity and undertake adaptive action. In most urban centres in low- and middle-income nations, community organizations and local NGOs also have considerable importance in this, especially where they are influential in the construction and management of homes and neighbourhoods and in the provision of services within the informal or illegal settlements where government agencies provide limited infrastructure or services.

Adaptation is all about the quality of local knowledge and of local capacity and willingness to act.[196] As described below, some of the most effective pro-poor actions to reduce vulnerabilities also come from partnerships between local government and community organizations. Most aspects of "development" increase adaptive capacity because they also increase local knowledge and local capacity to act. Successful development should also increase the incomes and asset bases of poorer groups and improve their health, which in turn increases their capacity to act to reduce their vulnerability. Development should also increase poorer groups' capacity to influence local governments and so spur them to appropriate action too.

A distinction is usually made between autonomous adaptation and planned or "policy-driven" adaptation (Table 9), and also between short- and long-run responses. (In discussions of development and of disaster preparedness, these might be termed "coping" and "adaptation" – although in other places, coping capacity is considered to be the same as adaptive capacity). There is also the distinction between reactive and anticipatory adaptation[197] – the former taking place in response to an extreme event, the latter being undertaken before a perceived risk materializes.

Table 9: Examples of adaptation in practice

Type of response to climate change	Autonomous (by households, communities and firms)	Policy-driven
Short-run	Making short-run adjustments, e.g. reducing water use, spreading the risk of loss through insurance	– Developing greater understanding of climate risks and vulnerabilities – Improving emergency response
Long-run	Investing in climate resilience – much encouraged if future effects are relatively well understood and benefits are easy to capture for household, community organization or firm	– Investing to create or modify major infrastructure, e.g. larger reservoir storage, increased drainage capacity, higher sea-walls – Avoiding negative impacts, e.g. land-use planning to restrict developments in floodplains and at-risk coastal sites

SOURCE: Based on table 18.1 in Stern, Nicholas (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, 692 pages.

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[194] McCarthy, James J., Osvaldo F. Canziani, Niel A. Leary, David J. Dokken and Kaskey S. White (editors) (2001), *Climate Change 2001; Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 1,032 pages.

[195] Adger, W.N., S. Agrawala, M. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit and K. Takahashi (2007), Chapter 17: *Assessment of Adaptation Practices, Options, Constraints and Capacity* in Parry, Canziani, Palutikof, van der Linden and Hanson (editors), op. cit. pages 717-743.

[196] Of course, this depends on the powers and supports provided by higher levels of government and international agencies – as discussed in Section V below.

[197] Bosello, Francesco, Onno Kuik, Richard Tol and Paul Watiss (2007), *Costs of Adaptation to Climate Change: A Review of Assessment Studies with a Focus on Methodologies Used*, Ecologic, Berlin, 112 pages.

From a temporal perspective, adaptation to climate risks can be viewed at three levels: including responses to current variability (which reflects learning from past adaptations to historical climates); observed medium- and long-term trends in climate; and anticipatory planning in response to model-based scenarios of long-term climate change. The responses across the three levels are often intertwined, and might form a continuum.[198] The fact that there is little or no locally relevant information on climate variability and trends in most urban centres is obviously a huge constraint on adaptation.

City and municipal governments should have key roles in adaptation in what they do and invest in, and in what they encourage and support in regard to adaptation by individuals, households and community organizations and private enterprises. This includes ensuring that there is an appropriate and widely understood information base about climate change and its likely local impacts to encourage autonomous adaptation. It includes the planning and regulatory framework to ensure effective land-use planning (avoiding high-risk areas which as emphasized above also means ensuring low-income groups can find land-for-housing that they can afford that is not on a dangerous site) and ensuring that buildings and infrastructure take account of climate-change risks (again in ways that do not impose additional costs that are unaffordable). It also means ensuring that planning and public-sector investment decisions take account of climate change.[199] To be effective, this not only has to reduce the vulnerability of urban dwellers and infrastructure but should also address the factors that generate both vulnerability and poverty, without undermining mitigation.[200]

It is important to note the costs of adaptation and the limits. Note the wording that adaptation is to "cope better" with stresses; it does not imply that adaptation allows avoidance of all costs. While there are important complementarities between good development and adaptation to climate-change risks, most adaptation implies opportunity costs – even if there are often good cost-benefit ratios. In addition, although adaptation "can mute the impacts of climate change, it cannot by itself solve the problems posed by high and rapidly increasing temperatures. Even for relatively low amounts of warming, there are natural and technical constraints to adaptation – as is made vividly clear in low-lying coastal regions. Equally, without strong and early mitigation, the physical limits to – and costs of – adaptation will grow rapidly."[201]

Perhaps more worryingly, adaptation depends on much-increased local competence and capacity, and willingness to act by city and municipal governments – which official bilateral aid agencies and multilateral development banks were not set up to support. The structures of these international agencies and the modes of providing grants, soft loans (with grant elements) or non-concessional loans were never designed to support the kinds of pro-poor local development that is central to good adaptation in low- and middle-income nations. In part, this is the legacy of the 1950s conception of development assistance which centred on capital to help national governments invest in productive activities and infrastructure supported by "expert" foreign technical assistance. Although the understanding of how international agencies can support development has changed greatly since the 1950s, the basic structure of how funds are transferred from official donors to "recipient national governments" has changed much less. This is a point to which this paper returns in Section V.

Financial systems that encourage adaptation

There is a long history of driving risk management through pricing risk, providing incentives to reduce risk and imposing risk-related terms on policies.[202] Insurance can spread risks and reduce the financial hardships faced by individuals and enterprises linked to extreme events; it can also provide incentives for adaptation and risk reduction.[203] "To increase their capacity in facing climate variability and change, insurers have developed more comprehensive or accessible information tools" – for instance risk

[198] Adger, Agrawala, Mirza et al. (2007), op. cit.
[199] Adapted from Stern (2007), op. cit.
[200] Adger, Agrawala, Mirza et al. (2007), op. cit
[201] Stern (2007), op. cit., page 469.
[202] Kovacs, P. (2006), "Hope for the best and prepare for the worst: how Canada's insurers stay a step ahead of climate change", *Policy Options*, Dec/Jan, pages 53–56.
[203] Adger, Agrawala, Mirza et al. (2007), op. cit.

assessment tools – and "have fostered risk prevention through implementing and strengthening building standards, planning risk prevention measures and developing best practices and raising awareness of policyholders and public authorities".[204] The extra costs of insurance can act as a disincentive for households or enterprises taking risks – for instance building on areas of high flood risk. Governments need to establish policies that provide individuals and firms with better information about climate change, and better regulatory frameworks to help markets stimulate adaptation.[205]

Particular challenges here include the risks of "adverse selection" and "moral hazard". Adverse selection is when insurance is bought by only those who are certain, sooner or later, to suffer loss. For example, only those on floodplains buy flood insurance, and this works against the spreading of risk over a large population (as with, for instance, fire insurance). Moral hazard is when insurance unintentionally encourages more risk-taking (when those with insurance make less effort to avoid risk).[206]

One area of growing interest is the use of insurance as a means of spreading and reducing the losses from climate-related events for those who would not normally be considered as potential policy holders: low-income households and small businesses in low- and middle-income countries.[207] There is also an interest in the potential for public/private partnerships between governments and insurance companies to help realize this. This is important in view of the failure of purely market-driven processes to provide adequate insurance at affordable rates. The use of private insurance is far lower in low- and middle-income countries than in high-income countries.[208] For example, only 150,000 houses out of 16 million (i.e. less than 1 per cent) had disaster insurance coverage in Mexico in 1998. Insurance coverage for the Venezuela floods in 1999 amounted to only 1.4 per cent of total losses.[209] Only 1 per cent of households and businesses in low-income countries and only 3 per cent in middle-income countries have catastrophe insurance, compared to 30 percent in high-income nations.[210]

Public-private partnerships have been suggested where "…the public sector sets a rigorous framework to reduce the physical risks, provides cover for high levels of risk or segments with high administration costs and sets the rules for a private market for other risks, while the private sector provides services and offers coverage for lower levels of risk and segments that are more easily accessible."[211] But in most cities, governments do not provide the framework for risk reduction for lower-income households. It is difficult to see how insurance companies can offer good coverage at affordable premiums to low-income households that live in particularly dangerous sites to which governments will not provide infrastructure. The potential of public-private partnerships to address other development issues such as improving provision for water and sanitation for low-income households in urban areas has long-been greatly over-stated[212] and there is a danger that it will be overstated for insurance too.

As highlighted by events such as 2005 Hurricane Stan in Mexico and Guatemala, individuals bear most of the cost and manage it through the solidarity of family and other networks, if at all. Some exploratory insurance schemes have been initiated in India and Ethiopia, and the Bangladesh National Adaptation

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[204] Ibid., quoting Mills, E. and E. Lecomte (2006), *From Risk to Opportunity: How Insurers Can Proactively and Profitably Manage Climate Change*. Ceres, Boston, MA, USA, 42 pages; CEA (2006), *Climate Change and Natural Events – Insurers Contribute to Face the Challenges*; Comité Européen des Assurances, Paris, France, 27 pages; ABI (2004), *A Changing Climate for Insurance – A Summary Report for Chief Executives and Policymakers,* Association of British Insurers, London, 20 pages.
[205] Stern (2007), op. cit.
[206] Burton, I. (2006), "Climate change insurance", *Tiempo: a Bulletin on Climate and Development,* No. 58, page 26.
[207] Mechler, R., J. Linnerooth-Bayer and D. Peppiatt (2006), *Disaster Insurance for the Poor? A Review of Microinsurance for Natural Disaster Risks in Developing Countries*, Provention Consortium, Switzerland/IIASA, Austria.
[208] Wilbanks, Romero Lankao et al. (2007), op. cit.
[209] Charvériat, C. (2000), *Natural Disasters in Latin America and the Caribbean: An Overview of Risk*, Inter-American Development Bank, Washington DC.
[210] Munich Re (2005), *Natural Disasters according to Country Income Groups, 1980-2004*, Munich Re NatCatSERVICE, Munich.
[211] Dlugolecki, Andrew and Erik Hoekstra (2007), "The role of the private market in catastrophe insurance", in Gurenko, Eugene N. (editor), *Climate Change and Insurance: Disaster Risk Financing in Developing Countries*, Earthscan Publications, London, page 648.
[212] Budds, Jessica and Gordon McGranahan (2003), "Are the debates on water privatization missing the point? Experiences from Africa, Asia and Latin America", *Environment and Urbanization*, Vol. 15, No. 2, pages 87-114.

Programme of Action (NAPA) included micro-insurance as a priority project, but experience so far is insufficient to warrant large-scale deployment of insurance as a means of supporting adaptation to climate change.

Another area of interest is in learning from measures that low-income groups already employ to spread risk and reduce their vulnerability. For instance, community-managed savings groups are very common in urban areas, although they take many forms. These typically allow their members to have access to funds from pooled savings for sudden expenditures (e.g. school fees) or shocks. They can develop into larger networks of savings groups that not only spread the risks but also expand and extend the scope of what can be funded – and what can be negotiated from governments. Perhaps the best-known urban examples are the federations of savings groups among those living in "slums" or informal settlements. These are active in 15 nations, involving communities in risk management and also in many initiatives to improve housing and infrastructure, including "slum" and squatter-settlement upgrading, securing land tenure, developing new housing that low-income households can afford, and improving provision for infrastructure and services (including water, sanitation and drainage).[213] Of course, almost all of these also increase resilience to climate-change related risks.

Micro-finance is another way of providing low-income groups with more control over their finances, and can also help poor people to cope with climate-change impacts. It has been used to good effect by the Grameen Bank of Bangladesh, whose pioneering use of group lending contracts with joint liability has reduced the problems of "moral hazard" and "adverse selection" where households are too poor to offer collateral. But group lending contracts will fall apart if everyone involved experiences the same crisis, so government underwriting is necessary for them to be of any use in the face of climate-change-related disasters. There are also dangers in overstating the value of micro-finance. Low-income groups have very limited capacities to save and to pay, and all loan schemes have dangers of locking them into debt burdens they find hard or impossible to manage. It works best when it finances something that directly increases incomes (micro-enterprise loans) or directly reduces expenditures (in some circumstances, better, safer housing with formal services including good health care can do this). There are also other examples of financial services that benefit low-income households whose scope might be increased to cover some disaster risks – for instance the financial services provided to members and their families by the Self Employed Women's Association (SEWA) in India.[214]

Urban management/governance

Those who live in cities in high-income nations take for granted a range of local organizations important for providing protection from environmental hazards and disasters, for resilience to potential disasters and for adaptation. Virtually all urban centres in high-income nations have high adaptive capacity; virtually all their populations also have infrastructure and services that protect them from environmental hazards (such as universal provision for safe, sufficient piped-water supplies, provision for sewers and drains, all-weather roads and electricity) or help them cope when illness or injury occurs (health care and emergency services). Most have insurance for homes and possessions. Compared to virtually all cities in low-income nations and most in middle-income nations, existing buildings and infrastructure have been built and maintained to much higher standards of resilience. The powers and resources available to city and municipal governments are also much larger. And such governments are held accountable through being supervised by elected politicians. Whatever the limits and examples of government failures, there is much greater adaptation capacity.

Above sections have outlined the lack of adaptive capacity and the very large backlogs in provision for infrastructure and services in most urban centres in low- and middle-income nations. Most city and municipal governments there have almost no investment capacity at all; there are exceptions – as

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[213] Patel, Sheela, Sundar Burra and Celine D'Cruz (2001), "Shack/Slum Dwellers International (SDI); foundations to treetops", *Environment and Urbanization*, Vol. 13 No. 2, pages 45–59; D'Cruz, Celine and David Satterthwaite (2005), *Building Homes, Changing Official Approaches: The Work of Urban Poor Federations and their Contributions to Meeting the Millennium Development Goals in Urban Areas*, Poverty Reduction in Urban Areas Series, Working Paper 16, IIED, London, 80 pages; Mitlin, Diana and David Satterthwaite (2007), "Strategies for grassroots control of international aid", *Environment and Urbanization*, Vol. 19, No. 2, pages 483-500.

[214] Enarson (2004), op. cit.

examples given in this section will show – but they are exceptions. Most have political structures that have limited or no accountability to their citizens – especially the lower-income groups who are most vulnerable to most external stressors. Many have governments that actually increase the vulnerability of most of their lower-income citizens. It is difficult to conceive of a city government that is currently refusing to provide half its population with basic infrastructure and services and busily undertaking large forced-eviction programmes (so often justified by "city development") as a government likely to invest in appropriate adaptation. Table 10 illustrates how the competence and capacity of local governments influences what is possible and what local adaptation processes should be supported by external agencies.

Table 10: Different local contexts through which national governments and international agencies can pursue "good governance" for adaptation

Resources available to local government	The quality of local government/governance	
	From democratic and accountable local government structures…	**…to undemocratic, unaccountable and often clientelist local government**
From relatively well-resourced, local government institutions with the needed technical competence	Local government can channel external funding, including funding to support adaptation by households and private enterprises, and funding for needed infrastructure and support services (whether provided by community organizations, NGOs, private enterprises or government agencies)	Long-term support needed for governance reforms at all levels of government; also support needed for local private and community provision both to improve conditions and to build local pressure on government for better governance
...to poorly resourced local governments lacking funding, a strong local revenue base and technical capacity	Need for a strong focus on capacity building for local government and support for its partnerships with civil society and local private-sector infrastructure and service providers (including informal providers)	As above but with strong support for local private providers and community provision within a long-term goal of supporting more competent, accountable and transparent local government

However, rather than dwell further on the inadequacies in local governments (and the governance systems of which they are part), it is worth looking at some of the exceptions, especially those that have begun to give attention to adaptation. The following sub-section is about the adaptation plans and processes in Durban, one of South Africa's main cities. This is not to pretend that this is a model – and as the text below (and the longer papers on which it draws) makes clear, it is difficult for those in the government with responsibility for environmental management to get and keep the attention of all the key sectors within the city government on adaptation. But it is an example of the kinds of local processes that are needed to underpin adaptation.

Durban's adaptation plans and processes[215]

Discussions within Durban on adaptation to climate change are at an early stage, seeking to determine what should be done to reduce vulnerability. This is being led by the Environmental Management Department of eThekwini Municipality (the local authority responsible for managing Durban) but it seeks to engage all sectors; this department has also begun to lead by example – for instance considering how to redesign the city's open-space system to make it (and the globally important biodiversity it contains) more resilient to climate-change pressures.

The Environmental Management Department has been aware of climate-change issues since its establishment in 1994[216] but given the major post-apartheid development challenges that Durban faces – and the restructuring of local government – it took several years before climate change emerged as an issue of significance on the city's agenda. At present, the adaptation actions being taken outside those of the Environmental Management Department are not a direct response to climate change but a spin-off

[215] This summary is based on notes and materials provided by Debra Roberts, deputy head of the Environmental Management Department at eThekwini Municipality, and including a report that she commissioned: Hounsome, Rob and Kogi Iyer (2006), *eThekwini Municipality; Climatic Future for Durban Phase II: Headline Climate Change Adaptation Strategy*, Final Report, prepared at the request of the Environmental Management Deartment, eThekwini Municipality, CSIR, Congrelli, 45 pages.

[216] It was initially named the Environmental Management Branch.

from actions taken to address more mainstream concerns – such as better management of water resources. However, some departments are being proactive – for instance the health authorities are looking at changes in the distribution of malaria under various climate-change scenarios.

The first investigation into the feasibility of establishing a climate-protection project was in 1999 – but a lack of resources and the need to deal with other "higher priority" issues resulted in little action after the initial investigation. In 2001, some external support from USAID to the national government's Department of Environmental Affairs and Tourism for a South African programme to address global climate change included a component to engage a group of South African cities. This was done through city governments' participation in what was then known as the Cities for Climate Protection Campaign, managed by the International Council for Local Environmental Initiatives (ICLEI) – although this focused on mitigation rather than adaptation. This supported the preparation of the first inventory of greenhouse-gas emissions in Durban and supported the initiation of an energy-efficiency pilot project for which audited eleven municipal buildings and the implementation of no- or low-cost energy-efficiency measures in two of them. But there was little internal institutional momentum built around these – as is often the case with externally mediated and funded interventions (see also the relevance of this point in relation to discussions below on national level action).

In 2004 the Deputy Head of the Environmental Management Department ran a series of seminars on climate change for municipal officials, after participating in a four-month environmental management programme in the USA (which had provided her with the first opportunity to engage with the science of climate change and its impacts). Discussions at these workshops highlighted the fact that the climate-change debate happens largely at the global level, with very little work done in translating this into an understanding of local-level impacts. **Municipal officials are unlikely to act, if they have little idea of what climate change means for their city.** In response to this, the "Climate Future for Durban Programme" was initiated, with the Council for Scientific and Industrial Research (CSIR, a parastatal research organization) in 2004.

This programme has had three phases.

1. Reviewing and developing an understanding of global and regional climate-change science and translating this into an understanding of the implications of climate change for Durban.
2. Developing a "Headline Climate Change Adaptation Strategy" for the city, to highlight how key sectors within the municipality should begin responding to unavoidable climate change.
3. Incorporating climate change into long-term city planning; the municipality and CSIR are working with the Tyndall Centre for Climate Change Research (in the UK) to develop a model that will enable the simulation, evaluation and comparison of strategic urban development plans within the context of climate change. This seeks to develop a greater understanding of the effects of climate change in Durban (and of greenhouse-gas emissions) and to allow a model-based assessment of the effectiveness of alternative strategic approaches to mitigation and adaptation.

The report on the Headline Climate Change Adaptation Strategy[217] was completed in 2006, following detailed discussions with municipal line departments. Based on general trends predicted for Durban, the focus was to:

- discuss in more detail sectoral climate-change impacts, Durban's vulnerability to these impacts and plausible adaptation options;
- gain insights into how the various departments within the municipality engage with the issue of climate-change adaptation;
- identify departmental initiatives (both current and future) that will facilitate adaptation;
- highlight research opportunities.

Since the Headline Climate Change Adaptation Strategy was produced, the city has had several major storm events, resulting in extensive infrastructure damage. For instance, particularly high tides and waves along the coast in March 2007 damaged municipal infrastructure which will require R60 million to repair (and a further R60 million if damage to private property and infrastructure were factored in).

[217] Hounsome and Iyer (2006), op. cit.

Although this cannot be attributed to climate change, it began sensitising the government to the possible severity of impacts from the increased frequency and/or intensity of extreme weather events that climate change is likely to bring. This led to the proposal that a Shoreline Management Plan be developed as a matter of urgency, to manage and defend the coastline and its infrastructure.

For Durban, the Headline Climate Change Adaptation Strategy includes a detailed table with predicted changes and likely effects of climate change, 2070–2100, which listed key impacts on infrastructure, human health, food security and agriculture, water, tourism/business, and biodiversity and the coastal zone. This makes clear the relevance of climate-change issues for virtually all departments and agencies within the municipal government. Below is a summary of the key likely impacts for Durban and some of the adaptation options. It is worth reviewing the complete document because this illustrates the importance of locally generated adaptation strategies – and shows the kind of document that all urban centres need. So much of what needs to be done and what can be done is defined or strongly influenced by local contexts. In addition, local politicians and civil servants are unlikely to act on climate change unless its immediate relevance for their city and their sectoral concerns are made evident.

Human health: Some impacts are direct, e.g. heatwaves and extreme weather disasters; others arise through disturbances to ecological processes, e.g. on infectious diseases, freshwater supplies and food availability. Certain groups are more vulnerable to these. The municipal government would have to respond to greater risks of heat-related deaths and illnesses, extreme weather (note the vulnerability of sewage networks and of informal settlements to flooding), potentially reduced air quality, and impacts of changes in precipitation, temperature, humidity and salinity on water quality and vector-borne diseases. There is a need for public education, to develop community responses, to ensure that electricity supplies can cope with peaks, to promote more shade provision and increased water efficiency, and to develop an extreme-climate public early-warning system, and research and training for environmental health

Water and sanitation: Durban already faces constraints on water supplies, with water resources presently under threat. There is a need for integrated water-resource management plus adaptive responses on both supply and demand sides. The water and sanitation agency is already implementing some adaptation options to reduce the volume of freshwater needed. Arguably, for Durban, adaptation for changes in water availability is the most important adaptation measure. There is a need to evaluate the capacity of infrastructure to supply water within an uncertain climatic future, so that it can cope with variable rainfall and increased flows during flooding events, and also to understand future demands. Adaptation measures to investigate include increasing the water-absorbing capacity of the urban landscape, making improvements to urban drainage, increasing the height of natural shoreline stabilization measures, utilizing storm-water retention/detention ponds and constructed wetlands, adjusting storm-sewer design, land-use planning and zoning to avoid locating structures/buildings in risky areas (and a need here too for mapping in resetting one-in-fifty-year flood lines). There are also several measures to reduce water demand that effectively increase available supplies, including working with industry.

Coastal zone: Coastal environments, settlements and infrastructure are exposed to a range of marine and land-based hazards such as storms, associated waves and storm surges, river flooding, shoreline erosion and influx of biohazards e.g. algal blooms. It is possible that that these existing impacts will intensify under climate change. Possible impacts of climate change on Durban's coastline, particularly in regard to sea-level rise, have already been incorporated into the work of the municipality's Coastal, Storm Water and Catchments Management Department over the last two decades and this is expected to continue. Mapping of 1:100 and 1:50 floodlines for 90 per cent of rivers has been completed, within a programme to inform citizens and support adaptation. New developments need catchment management plans to ensure that excess runoff is contained on site. Development set-back lines and potential erosion lines have been identified that incorporate 1:50 sea storms and a 50-year sea-level rise prediction. There is concern that the port does not have development setback lines. The mapping programme underway will show sites at risk; from this there is a need to develop plans to manage flood risks, identify communities most at risk, support responses or relocation, and avoid future developments in flood-prone areas. The municipality is investing in developing the city's coastline for tourism, with key development areas along the coastline planned for the next 10–20 years. Rises in sea level could affect these developments, if not

properly taken into account. Natural systems in Durban are capable of adapting to a 20 cm rise – but they may need to cope with much more than this.

Biodiversity: There is a need to understand and address this issue at local level. The first step could be to develop stronger knowledge on the likely impacts on biodiversity of the many likely effects of climate change.

Key infrastructure at risk: Built systems need to endure greater exposure to extreme weather events, including extreme precipitation and windstorms. Infrastructure design is generally based on past climatic conditions, but these are no longer accurate indicators for planning, maintenance and upgrades. New guidelines are needed for municipal infrastructure to ensure safety and quality of life and to reduce long term costs.

Electricity supplies: These should have no problem in adapting to gradual change, but difficulties are likely in response to extreme events. The electricity agency has no written policy but has responded to various initiatives. There is need for review of how to cope with some climate-change effects, and to engage in mitigation.

Transport: It may be necessary to revise road-construction standards, and to avoid routes at high risk of flooding. There are also many measures available to reduce emissions from the transport sector.

Food security and agriculture: Support is needed for local agriculture, and there should be attention to the impacts of climate change on commercial agriculture.

Disaster-risk reduction: Durban has disaster-management strategies but these have largely focused on technological disasters (the city is an important industrial centre, including petrochemicals) and flooding. These strategies are not engaged with the need for disaster-management strategies in relation to extreme weather events, or with city health-emergency plans in response to climate change. There is also a need to shift from being responsive to disasters and towards being pro-active in minimizing hazard, reducing exposure and susceptibility, and enhancing coping and adaptive capacity. There is a need for more attention to early warning, more resistance in construction, the avoidance of risky sites and attention to accidents in potentially dangerous industries.

Cross-sector municipal activities: There is a need to build awareness, encourage policy changes and develop strong public education and outreach. There should be support for local research and institutional capacity, and for community-based adaptation.

Innovations in other cities

There are other good examples of city governments taking steps to reduce vulnerability, such as in the cities of Manizales in Colombia and Ilo in Peru. Local governments here acted on one of the most difficult issues: avoiding rapidly growing low-income populations settling on dangerous sites – including those that will be most at risk from any increase in the frequency or intensity of extreme weather events. Neither of these local authorities was driven by climate-change considerations, but these examples illustrate the kind of pro-poor adaptive capacity that is needed.

Manizales was facing high rates of population growth, and environmental degradation. Lacking the resources to buy into the official land market, the poor increasingly settled spontaneously or bought land from illegal developers in areas at risk from floods and landslides. From the 1990s, local authorities, universities, NGOs and communities worked together to develop programmes aimed not only at reducing risks, but also at improving the living standards of the poor and at protecting and regenerating fragile ecological areas. Households were moved off the most dangerous sites but re-housed nearby, and most of the former housing sites were converted into eco-parks with strong environmental-education

components. This was part of a larger programme to improve environmental quality and make resource use more sustainable in ways that engaged and worked with citizens and community organizations.[218]

The inhabitants of Ilo and democratically elected mayors over seven consecutive terms engaged in the process of creating community-management committees to improve living conditions and the quality of the environment. Improvements were made in water supply, sanitation, electricity provision, waste collection and public space. Ilo's population increased fivefold during 1960–2000. Yet, no land invasion or occupation of risk-prone areas by poor groups looking for housing has taken place, because local authorities implemented programmes (such as the acquisition of an urban-expansion area) to accommodate Ilo's growth and to support the poor in their efforts to get decent housing conditions.[219] In Windhoek, the city government changed the land development regulations on minimum plot sizes and infrastructure standards which considerably reduced the prices of the legal plots.[220]

A recent paper has outlined the justification for the city of Cape Town developing a Municipal Adaptation Plan for climate change and what this should entail.[221] The city is at risk from projected climate-induced warming and changes in rainfall variability. This increases the need to adapt city-level operations to current climate variability and future climate change. To date, the main focus of adaptation planning in South Africa has been at the national level, and has not adequately addressed municipal-scale adaptation. The paper develops the adaptation framework around four main principles:

1. adaptation to short-term climate variability and extreme events should be included as the basis for reducing vulnerability to longer-term climate change;
2. adaptation policies and measures should be assessed in a developmental context;
3. adaptation should occur at different levels of society;
4. both the strategy and the process by which adaptation is implemented are equally important.

Eight steps are described, for developing a local or municipal adaptation strategy:

1. assess current climate trends and projections for the municipal area;
2. undertake a vulnerability assessment for each sector, and identify future vulnerabilities;
3. formulate strategy;
4. assess adaptation options;
5. evaluate priority adaptation strategies;
6. carry out programme- and project-scoping and design;
7. implementation;
8. monitoring.

The same paper also outlines the aspects of resource mobilization that need to be addressed during the development and implementation of a Municipal Adaptation Plan, and discusses some of the barriers to developing such adaptation plans.

Improved competence, capacity and accountability within city and municipal governments almost by definition increases adaptation capacity and increases the possibilities of it being "pro-poor". Examples of this in practice include the environmental and social programmes in Porto Alegre and many other Brazilian cities, and the importance within this of participatory budgeting.[222] However, such examples are mainly from middle-income nations and usually nations that have made advances in strengthening

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[218] Velasquez, Luz Stella (1998), "Agenda 21; a form of joint environmental management in Manizales, Colombia", *Environment and Urbanization*, Vol. 10, No. 2, pages 9–36; Velásquez, Luz Stella (2005), "The Bioplan: Decreasing poverty in Manizales, Colombia, through shared environmental management" in Bass, Steve, Hannah Reid, David Satterthwaite and Paul Steele (editors), *Reducing Poverty and Sustaining the Environment*, Earthscan, London, pages 44–72.

[219] Díaz Palacios, Julio and Liliana Miranda (2005), "Concertación (reaching agreement) and planning for sustainable development in Ilo, Peru", in Bass et al., op. cit., pages 254–278.

[220] Mitlin, Diana and Anna Mueller (2004), "Windhoek, Namibia: towards progressive urban land policies in Southern Africa", *International Development Planning Review*, Vol. 26, No. 2, pages 167-186.

[221] Mukheibir, Pierre and Gina Ziervogel (2007), "Developing a Municipal Adaptation Plan (MAP) for climate change: the city of Cape Town", *Environment and Urbanization*, Vol. 19, No. 1, pages 143–158.

[222] Menegat (2002), op. cit.; Cabannes, Yves (2004), "Participatory budgeting: a significant contribution to participatory democracy", *Environment and Urbanization*, Vol. 16, No. 1, pages 27–46.

local democracies and reducing anti-poor attitudes among those in government. Box 12 serves as a reminder of the lack of attention usually given to adaptation.

Box 12: The lack of attention to adaptation in cities: the cases of Buenos Aires, Santa Fe and Mexico City

BUENOS AIRES: The urban agglomeration of 14 million inhabitants with Buenos Aires at its centre extends from Zárate–Campana to Berisso–Ensenada and is located on the banks of the Rio de la Plata. The Paraná River delta is just to the north of Buenos Aires, and parts of it are within Tigre and San Fernando municipalities, which are part of Greater Buenos Aires. Floods are common occurrences in Buenos Aires; there were 35 floods in the metropolitan area from 1985 to 2003. With its close proximity to the Rio de la Plata, it is highly vulnerable to sea-level rise and storm surges – and from flooding from intense rainfall, because of the inadequacies in provision for storm and surface drainage. The Rio de la Plata hydrodynamic is set by the discharge of its tributaries (mostly the Paraná and the Uruguay), sea surge and winds. Floods in the Rio de la Plata are associated with the phenomenon known as "sudestadas" (south-easterlies), characterized by persistent, regular and strong winds coming from the south-east that help increase the river level by an effect called *apilamiento* which blocks the water coming from the river into the ocean. More south-easterlies are likely under climate change and will create more flood situations. In 100 years time, the Rio de la Plata is expected to have average water levels that are between 60cm and 1 metre higher than today, and stronger winds and storm surges. The areas with the higher risk are the Paraná Delta, the coastal zone that goes from Berazategui–Quilmes to Berisso–Ensenada (south of the metropolitan area) and the southern region of the Bahía Samborombón. Within Buenos Aires metropolitan area, the areas most at risk are the low-lying lands of the lower basins of the rivers Reconquista, and Matanza–Riachuelo, and these lands have high concentrations of informal settlements.[223] Buenos Aires has also had a significant increase in annual rainfall over recent decades and increasing numbers of intense rainfall events (with over 100mm in 24 hours).[224] An ambitious plan to address flooding in Buenos Aires is underway, with support from the World Bank. However, this has not taken into account climate-change variables, as it is claimed that there is not enough information to allow this. One long-term worry is the threat to the Paraná Delta, which is an important part of Buenos Aires's economy and also important as a natural flood-control mechanism; the growth of the delta has slowed, and erosion and floods may destroy it.[225]

SANTA FE: The city of Santa Fe in Argentina (with a population of over 400,000) has increasingly expanded onto the Río Salado floodplain. To defend the city from floods, embankments and dykes were created. A flood in 2003 resulted in 130,000 evacuees (one third of the city population), 23 official deaths (local sources suggest at least 100 more than this), 180 cases of leptospirosis, 200 cases of hepatitis and losses estimated at around US$1 billion. Among the factors contributing to the flood were increased rainfall (and more intense storms) and deforestation and land-use changes around the city – but the flood caught the city authorities completely unprepared. Floods in 2006 and 2007 also caught the government unprepared; there were several deaths, tens of thousands of evacuees, highways and roads flooded, and bridges down. A third of the city was turned into shallow lake – the same part of the city hit by the 2003 flood. The director of a local foundation noted: "there has always been heavy rains in the city of Santa Fe"; he also noted that the contingency plan for flooding existed only on paper and no one really knew what they were supposed to do. The pumps did not work because of inadequate maintenance and vandalism. He complained that local authorities favour the urbanization of at-risk areas by bringing piped water and electricity to the neighbourhoods, "where they have their loyal voters". But they fail to follow up with preparations for emergencies and do not maintain the pumps and drainage systems.[226]

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[223] Hardoy, Jorgelina and Gustavo Pandiella (2007), *Background Paper on Climate Change and Cities in Argentina*, paper prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience. This paper was based on a review of available literature and discussions with key informants, including academics working on climate-change issues and personnel from different government departments. The authors are with IIED-America Latina and both work closely with local governments on social and environmental issues. For the information presented here, it draws principally on Re Mariano y Ángel Menéndez (2007) "Impacto del Cambio Climático en las Costas del Río de la Plata", *Revista Internacional de Desastres Naturales, Accidentes e Infraestructura Civil*, Vol. 7, No. 1, Abril, Universidad de Puerto Rico, Recinto Universitario de Mayagüez, Puerto Rico (www.uprm.edu/civil/revistadesastres/Vol7Num1/2%20Re%20y%20Menendez.pdf); Frers Cristian, *El Cambio Climático Global y su influencia sobre la República Argentina. Impacto del Cambio climático en la Ciudad de Buenos Aires* (http://www.internatura.org/estudios/informes/el_cambio_climatico.html); Czubaj, Fabiola (2007), "Conclusiones del panel intergubernamental de las Naciones Unidas", Expertos advierten sobre los efectos del cambio climático en la Argentina, La Nación, Sección Ciencia y Salud, pág. 16, 11 abril.

[224] Drawn from Hardoy and Pandiella (2007), op. cit. The information presented here is primarily drawn from Atlas Ambiental de Buenos Aires (http://www.atlasdebuenosaires.gov.ar); Rebagliati, Ricardo (2003), "Plan Director de ordenamiento hidráulico y proyecto ejecutivo para el arroyo Maldonado del Gobierno de la Ciudad de Buenos Aires" in *Contactar, Ciudades Saludables*, No. 11 (www.revistacontactar.com.ar/plan_director_nro11.htm).

[225] El Delta crece menos de los esperado (2006), Centro de Divulgación Científica de la Facultad de Ciencias exactas y Naturales de la Universidad de Buenos Aires (UBA) (http://www.conicet.gov.ar/index.htm).

[226] Drawn from Hardoy and Pandiella (2007), op. cit. For the information presented here, Proyecto de Ley – Diputado Eduardo Di Pollina – Ley Nacional Indemnización Inundaciones Santa Fe; www_partidosocialista_com_ar –

MEXICO CITY: Since 2000, authorities in Mexico City have related climate change to air pollution and developed an integrated understanding of synergies between mitigation and pollution control. But little attention has been given to enhancing Mexico City's adaptation to floods, heat stress, water scarcity and other hazards likely to be aggravated by climate change. Furthermore, city authorities lack the institutional capacity (e.g. human resources, money and power) to deal with climate-related hazards.

Infrastructure adaptation and investment

This section discusses what has been done and what could be done in regard to infrastructure adaptation; the funding needed to support this is discussed in Section V. It had been hoped that there would be examples of city case studies that discussed the kinds of investment patterns needed for adaptation, in the context of different IPCC climate-change scenarios, but no examples of this were found. However, the examples given above of Durban and Cape Town show the kind of local discussion and research that provides the basis for adaptation – or perhaps more importantly, for considering how to integrate adaptation into development plans and infrastructure investments.

Most fields of infrastructure management already incorporate measures to cope with climate variability and extreme events – including water, sanitation, transport and energy management. Adaptation to climate change will typically involve increases in reserve margins and other types of back-up capacity, and attention to system designs that allow adaptation and modifications without major redesigns and that can accommodate more extreme conditions for operations.[227] But it is difficult to formulate these for any city without a clear idea of current trends and likely future impacts.

Planning for such adaptation faces very large infrastructure deficits. The poor quality of infrastructure and the lack of maintenance characteristic of so many low- and middle-income nations are key determinants of dams failing, and public hospitals, schools, bridges and highways collapsing during or after extreme weather events. There are complex issues of quality control and accountability for public works – for instance the lack of transparency in procurement, which frequently leads to corruption and poor-quality work. Decentralization has often transferred responsibility for infrastructure maintenance to state and local authorities, but without the resources and capacities to fulfil this. The collapse or damage to buildings and infrastructure obviously increases the indirect costs of climate disasters by paralysing economic activities and increasing the cost of reconstruction.[228] Intervention priorities have been detailed for India, to reduce climate-change-related risks for urban areas.[229] These have relevance for all urban areas, and are summarized as follows.

Building retrofitting and strengthening: A large proportion of a typical Indian city's building stock is aged, dilapidated and partially engineered, implying that they do not meet contemporary standards of building safety. Technical measures to strengthen and retrofit these buildings are well known, but have never been implemented at city scale. This would require considerable institutional and financial innovation and a considered set of incentives and regulatory mechanisms to make it possible.

Lifeline infrastructure strengthening: Building the energy, water, waste-water, transportation, telecom and IT infrastructure for large cities typically takes many decades. Given current growth trends, this will happen in many Indian million-cities over the next two decades. Appropriate risk-reduction measures in relation to climate change are rarely integrated into the design of these systems. Since they involve lumpy investments and require massive annual expenditures on operations and maintenance, attention should be given to least life cycle risk-adjusted costs. Some services are best provided by public providers within an appropriate regulatory frame, others – given major advances in technology and

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inundaciones santa fe.htm; Valente, Marcela (2007) Cambio Climático – Inundación Santa Fe: Aguas Violentas, Desidia Humana, Buenos Aires, 2 April (IPS) in: http://www.proteger.org.ar/doc621.html.

[227] Wilbanks, Romero Lankao et al. (2007), op. cit.

[228] Charvériat C. (2000), *Natural Disasters in Latin America and the Caribbean: An Overview of Risk*, Inter-American Development Bank, Washington DC, page 85.

[229] Revi (2007), op. cit.

distributed network development – are better managed privately. Appropriate forms of regulation and management to reduce climate risk are yet to be conceptualized.

Hazard modification: A number of pre-colonial and colonial surge- and flood-protection systems have been in operation in various parts of India. The rapid pace of urban development has often made these structures dysfunctional or irrelevant. Repairing and strengthening the strategic flood, storm-surge and coastal defences are important city-level interventions. Detailed economic, social and environmental cost-benefit analyses are needed to assess whether these investments are appropriate in relation to relocation and other adaptation options. Water-use efficiency and conservation measures are the best strategic defence against drought on the demand side, apart from appropriate water management. Enabling the conceptualization and implementation of institutional and technical regimes that can facilitate both vulnerability reduction and hazard modification is a significant challenge that needs to be explored through a series of pilot projects in different cities with varying ecological systems.

Upgrading slums and squatter settlements

Perhaps the most important experiences in regard to making poorer groups less vulnerable to climate change in cities are those that have successfully improved housing conditions and infrastructure and services within low-income settlements. There is a 40-year experience of upgrading "slums" and informal settlements and, although the extent of success is very varied, where it works, it certainly reduces poorer groups' vulnerabilities to flooding and extreme weather events. Many city governments support "slum and squatter" upgrading.[230] In some nations, these receive considerable support from national government – as in the *Baan Mankong* (secure tenure) programme in Thailand, supported by the Thai government's Community Organizations Development Institute[231] and in the PRODEL programme in Nicaragua.[232]

Community-based adaptation[233]

The best "slum and squatter" upgrading programmes can be seen as good examples of community-based adaptation; they may focus on addressing "everyday" hazards and protection against extreme weather but addressing climate change is often simply an extension to this. They are also a reminder of how vulnerability to all environmental hazards is strongly influenced by the adaptive capacities of those exposed to the hazards. In the new enthusiasm for mapping climate-change vulnerabilities, this is sometimes forgotten. In many instances, adaptive capacity is a stronger determinant of the distribution of vulnerability to climate change than differences in the biophysical responses – for instance in water resources, coastal areas or human health.

In recent years, more attention has been paid to community-based adaptation to climate change. But there is also uncertainty about its potential. How does this fit with other, more established development activities (such as community-based development and disaster planning) that have track records and their own ways of working? What makes it different from other forms of adaptation to climate change? What is particular to urban areas in regard to potentials and limitations?

Over the course of a workshop on community-based adaptation (CBA),[234] agreement was reached on a number of points.

- CBA is generally applied in vulnerable communities but it can be applied in any community.

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[230] For an overview, see Hardoy, Mitlin and Satterthwaite (2001), op. cit.; see also Budds, Jessica with Paulo Teixeira and SEHAB (2005), "Ensuring the right to the city: pro-poor housing, urban development and land tenure legalization in São Paulo, Brazil", *Environment and Urbanization*, Vol. 17, No. 1, pages 89–114.

[231] Boonyabancha, Somsook (2005), "Baan Mankong; going to scale with 'slum' and squatter upgrading in Thailand", *Environment and Urbanization*, Vol. 17, No. 1, pages 21–46.

[232] Stein, Alfredo (2001), "Participation and sustainability in social projects: the experience of the Local Development Programme (PRODEL) in Nicaragua", *Environment and Urbanization*, Vol. 13 No. 1, pages 11–35.

[233] Jones, Roger and Atiq Rahman (2007), "Community-based adaptation", *Tiempo* 64, pages 17-19.

[234] The Second International CBA Workshop in Dhaka in February 2007 was an initiative of the Bangladesh Centre for Advanced Studies, the International Institute for Environment and Development and the Regional and International Networking Group.

- It is about the community making choices, not having them imposed from above. It should enhance the choices available in regard to present or future action.
- Adaptation responds to climate risks assessed in a developmental framework, rather than to "dangerous" anthropogenic climate change as defined by the UN Framework Convention on Climate Change. The definition of climate and CBA's sphere of operation in relation to climate is therefore broader than defined under the convention.
- Change processes such as environmental degradation, poor governance or loss of access to land and resources often exacerbate risks faced by communities from climate-related causes.
- CBA should complement community-based development and community-focused disaster-risk reduction – and draw tools and methods from them. A wide range of tools can be used creatively for communication within projects, including drama, video, multi-media, intermediate technology, art and storytelling (drawing on a long and varied experience with the use of participatory tools and methods in urban and rural areas).[235]
- It should help development and disaster experts who are trying to learn more about incorporating climate adaptation into their own activities – but this will need some work on shared concepts and languages as these differ across climate adaptation, development and disaster discourses.
- There is a need for action-oriented research that investigates CBA at all levels – and that considers its limitations as well as its strengths. In urban areas, community-driven development can often install or improve infrastructure and buildings within the settlement – but also usually needs support from city-wide trunk infrastructure (roads, power supplies, water and sewer mains, main drains) which they cannot install.

As with the experience in the use of participatory tools and methods within development, care is needed to ensure everyone's involvement and engagement. Experience to date suggests three important stages for any CBA: (1) focus on addressing current climate risks within a development context, (2) monitor progress and look outward, and (3) assess future development options under climate change.

Stage 1: Ship-building. This addresses climate-related vulnerability by adapting to current climate risks, especially those shown to be consistent with those projected for the future. These risks are most often exacerbated by other human activities. This stage may have much in common with current disaster or development projects and need not have a strong emphasis on climate change as long as adapting to current climate risks remains a central focus.

Stage 2: Map-making. This stage monitors progress at the local level and brings in data and information from outside. It is mainly a reflexive stage where adaptation may continue but monitoring ongoing change (such as environmental and social change) also occurs so that the causes and management of risks become better understood. The progress of adaptation options can be quantified.

Stage 3: Exploring new horizons. This stage investigates how risks may change and be managed over time. The primary aim is to give communities a greater choice in their future. Projections of climate-change risks and development pathways may be investigated. Exploring new horizons does not imply that communities must move location or change activities, but if they continue along their historical pathway, they do so with a full understanding of what the alternatives may be.

This structure seeks to offers communities the opportunity to explore adaptation possibilities under different development approaches. Obviously, it needs to recognize that many political, financial and social barriers will hamper this process. These barriers need close examination, as do the strategies and mechanisms for addressing them. One key element of CBA is that of improving the capacity of individuals and communities to make choices about their own futures. In many instances, this will involve difficult decisions – for instance having to move – which makes it all the more important that people should be fully engaged in choices about where to move to, when, and how the move should be managed.

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[235] See various issues of *Participatory Learning and Action,* IIED, London, on-line accesshttp://www.ingentaconnect.com/content/iiedpla/pla

Box 13: Community-based adaptation – Cavite City, The Philippines

Cavite City is on a peninsular, surrounded by three bodies of water: Bacoor Bay, Canacao Bay and Manila Bay. Its population in 2003 was 104,000, about half of which is on the coast. Coastal communities have been adversely affected by climate variability and sea-level rise to varying degrees and are highly vulnerable to long-term climate change. Cavite City experiences an average of two tropical cyclones (within a 50-kilometre radius) every year. The eight tropical cyclones that struck between 1994 and 2001 displaced 40,000 people. Cavite City is also affected by drought (for example in 1968–69, 1982–83, 1987, 1991–93 and 1997–98) and increases in sea-level (+0.183m in 1970–80; +0.142 in 1981–90; +0.122 m in 1991–2000). Currently, some 10 per cent of the population is vulnerable to sea-level rise, but a one-metre increase would put around two-thirds of the population at risk.

Impacts of climate variability and sea-level rise include: coastal erosion, siltation and sedimentation, storm surges and flooding of urban areas, saltwater intrusion into groundwater resources and existing waterworks, degradation of water quality, and inundation of brackish water in estuarine areas.

Socio-economic group	Impact	Degree of impact
Small fishers	Decrease in fish catch, more damage to livelihoods and assets	Very high
Shellfish growers	Decrease in shellfish production, more damage to assets and livelihoods	Very high
Micro-entrepreneurs/self-employed	Decrease in sales/profits, relatively less damage to assets and livelihoods	High/moderate
Employed	Increase in commodity prices, relatively less damage to property/assets	Moderate
Better off	Decrease in production and income, less damage to property/assets	Low

Many autonomous adaptation strategies have positive outcomes for those implementing them, but they are limited in what they can achieve and they are not effectively integrated into existing local development plans. Autonomous strategies include:

- accommodating sea-level rise by building houses on stilts;
- strengthening/reinforcing the physical structure of houses;
- moving to safer places during calamities;
- placing sandbags along the shorelines;
- borrowing money from relatives, or from money-lenders (at very high interest rates);
- engaging in alternative income-generating activities locally or in other areas, or changing occupation.

Various government-planned adaptation strategies (such as relief assistance, resettlement and shoreline-protection measures) have reduced the vulnerability of coastal households, but the measures are inadequate and costly (US$2.15 million per kilometre of shoreline protection structures, and US$4.2 million for drainage systems). Consultation workshops, focus-group discussions and key informant interviews have revealed that communities feel they only have poor-to-fair human, physical and financial capacities. People expressed significant concern over climate risks, and proposed several adaptation strategies, many of which were non-structural, capacity-enhancing measures.

Ways forward

POLICY AND INSTITUTIONAL REFORMS

- Develop and implement a climate-change, adaptation-sensitive government and integrated coastal zone management policy and plan that integrates land- and sea-use zoning, alternative livelihood development and eco-waste management.
- Evaluate and prioritize proposed structural and non-structural options, including the provision of secure property rights and micro-finance/insurance schemes that enhance the adaptive capacity of vulnerable groups.
- Review existing government Calamity Fund allocation to cover disaster preparedness and local adaptive capacity development.
- Examine potential synergy of existing local institutional mechanisms for disaster risk management, fisheries/aquatic-resource management, and community-based adaptation.

CAPACITY DEVELOPMENT

Build local capacity on climate-change adaptation and integrated coastal management through: awareness/knowledge; participatory risk/vulnerability/adaptation assessment and planning; legislation and regulation; building a multi-sectoral integrated coastal zone management body; organizational and management leadership development; alternative livelihood development; programme/project development and management; law enforcement; resource mobilization; and micro-finance/insurance. Also, mobilize NGOs and local academic/research

institutions to provide support for community organizing/mobilization, participatory risk and resource assessment and policy advocacy.

IMPROVING KNOWLEDGE MANAGEMENT

- Establish community-based monitoring and surveillance systems to measure changes in coastal areas for input into vulnerability and adaptation assessments, and planning and establishment of community early-warning systems.
- Conduct further research to advance understanding of the interrelationships between vulnerability, adaptation and climate variability and change, with specific focus on the following: socio-economic impacts of climate hazards; links between poverty, vulnerability and gender concerns; and documentation, sharing and promotion of traditional knowledge, skills and practices that enhance adaptation.

SOURCE: Faustino, R. (2007) *Mainstreaming Adaptation Towards Integrated Coastal Management: The Case of Cavite City, Philippines*. Presentation by Dr Ramon Faustino Jr, Assistant Director, Conrado Benitez Institute for Sustainability, Philippines, at the Community Based Adaptation Workshop, Dhaka, 24–27 February.

Planning to reduce disaster risk

There is some experience to draw on from cities that have integrated disaster-risk reduction into their development plans. For instance, in Caracas, where large sections of the population live on slopes at risk of landslides, there is a long-established programme, identifying which areas and settlements are at risk and acting to reduce these risks.[236] All cities need well-conceived disaster-risk management plans, both to reduce disaster risk and to have in place appropriate responses when disasters occur. This can and should be undertaken as an integral element of development (mainstreaming risk reduction in urban development decisions); this also means acting to tackle risk that has accumulated during the city's growth (retrofitting houses, improving critical infrastructure). All these provide opportunities and an institutional and organizational framework for integrating adaptation to climate change into urban planning.

In some cities (such as Istanbul, with its Metropolitan Municipality's Disaster Coordination Center) disaster-risk-reduction planning has been possible as development professionals are more used to considering risk-management measures. Here the challenge has been to bring together professionals, techniques and priorities from engineering and social development. In Cape Town, legislative arrangements require local disaster-risk management plans but progress has been slow. Here it is not development planners but emergency planners who have responsibility for planning and implementing disaster-risk reduction and they feel uneasy, venturing into areas in which they have little expertise.[237] In Manila, the Metro Manila Disaster Coordination Council coordinates disaster-response activities in the 17 cities and municipalities comprising Metro Manila and still has a strong focus on the emergency side.

The Earthquakes and Megacities Initiative reviewed disaster-risk management practices in seven cities (Bogotá, Istanbul, Kathmandu, Manila, Mumbai, Quito and Tehran). In all cities, considerable effort had been expended on risk analysis – but far too little attention had been given to acting on it. Generally, construction codes, standards and regulations were up to date, but without effective mechanisms to ensure compliance and code enforcement. To do this requires political commitment, funding, professional capacity and buy-in from households and civil society to overcome resistance from the construction sector and building owners. This is a major challenge to the effectiveness of urban disaster-management planning.[238]

It has been suggested that after large disasters a window of opportunity opens for political will for reform of urban planning systems and budgets. But there is little evidence to show that disaster preparedness and risk reduction become institutionalized. All too often, the next development challenge or political agenda replaces disaster-risk reduction and the opportunity is lost. After Hurricane Mitch, there was progress in

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[236] Jimenez Diaz, Virginia (1992), "Landslides in the squatter settlements of Caracas; towards a better understanding of causative factors", *Environment and Urbanization*, Vol. 4, No. 2, pages 80–89.
[237] Pelling, M. and A. Holloway (2007), *Legislation for Mainstreaming Disaster Risk Reduction*, Tearfund (http://www.tearfund.org/webdocs/website/Campaigning/Policy%20and%20research/DRR%20legislation.pdf).
[238] Fernandez, J., F. Bendimerad, S. Mattingly and J. Buika (no date) *Comparative Analysis of Disaster Risk Management Practices in Seven Megacities*, Earthquakes and Megacities Initiative (http://emi.pdc.org/DRMlibrary/General/Comparative-analysis-DRM-in-7-megacities.pdf).

introducing new legislation but urban concerns were not fully addressed, especially the links between disaster management and urban management, so urban planning was not fulfilling its potential in contributing to risk-reduction.[239]

In many cities, civil society may be more receptive than local government to disaster-risk reduction. The IPCC WGII noted various examples of where disaster preparedness at community level had helped to reduce death tolls – for instance through new early warning systems and evacuation procedures (and the identification of safe places for evacuating to); it also noted the unevenness in the effectiveness of such systems in reaching marginal populations. Even where decentralization has strengthened the capacities of local government, it is difficult to get cross-department agendas such as disaster-risk reduction working. Specific sectors managed at the local level, like water, housing, transport and education, can be key allies in mainstreaming disaster-risk reduction and indeed may already be undertaking actions that could be described as reducing risk.[240] But less is known about the development and application of disaster management plans in smaller urban centres where the capacity of local government and civil society is limited. Evidence from the Indian Ocean Tsunami suggests that these smaller settlements are less likely than larger centres to have disaster management plans and that in reconstruction citizens and officials will be less prepared and less able to work effectively with external agencies for local benefit.

Tools and methods

Over the last decade, a number of international initiatives and a wide range of local studies have developed tools and methods for identifying, mapping and modelling disaster risk, and its components of vulnerability, capacity and hazard.[241] This provides a strong base for building assessments of risk to climate change. Even if it is difficult to forecast how the local impacts of climate change will be felt in the future, planning for needed adaptive capacity in relation to climate variability can start this, identifying specific predicted hazard scenarios and measuring vulnerability and capacity.[242]

Most work on the assessment of vulnerability and capacity has been undertaken at the local level. Many methodologies exist, and most follow similar formats rooted in the use of either rapid appraisal and participatory methodologies (for instance time-line analysis, focus group discussions, wealth ranking, transect walks, hazard and vulnerability ranking exercises) or more statistically rigorous household surveys. The latter are often used by external agencies to feed into planning investments for disaster-risk reduction. The former are usually initiated by external actors but can include a significant element of local control such as a presumption that any outcomes must be analysed by local actors who also lead any attempts to gain support for subsequent risk-reduction activities. A good example comes from the Dominican Association for Disaster Mitigation, which has worked with at-risk communities in Santo Domingo and smaller settlements in the Dominican Republic. This Association trains local people to undertake risk assessments and develop proposals for risk-reduction initiatives. Local groups have subsequently had success in attracting government and donor support for local hazard-mitigation and infrastructure upgrading projects. The most important outcome, however, is arguably the enhanced skill and confidence that accrues at the local level through this encounter with a participatory risk assessment methodology.[243]

Up-scaling presents a particular challenge for local assessment methods. How to connect local data

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[239] Gavidia, J. and A. Crivellari (2006), "Legislation as a vulnerability factor", *Open House International*, Vol. 31, No. 1, pages 84–89, quoted in Chapter 11 of UN-Habitat (2007), op. cit.

[240] Pelling, M. (2007), *Making Disaster Risk Reduction Work*, ProVention Forum 2007, ProVention Consortium (http://www.proventionconsortium.org/themes/default/pdfs/Forum_2007_report.pdf).

[241] Pelling, M. (2006), "Measuring vulnerability to urban natural disaster risk: benchmarks for sustainability", *Open House International*, special edition on managing urban disasters, Vol. 31, No. 1, pages 125–132; Enarson, Elaine, Lourdes Meyreles, Marta González, Betty Hearn Morrow, Audrey Mullings and Judith Soares (2003), *Working with Women at Risk: Practical Guidelines for Assessing Local Disaster Risk*, International Hurricane Center, Florida International University, Miami, 95 pages.
http://www.gdnonline.org/resources/Working%20w%20Women%20English%20.pdf

[242] For a constantly updated collection and review of community risk assessment and climate adaptation tools see http://www.proventionconsortium.org/?pageid=32&projectid=13

[243] Pelling, M. (2003), *The Vulnerability of Cities*, Earthscan, London; and
http://www.desastre.org/home/index.php4?lang=esp

collection and planning visions with municipal planning goals and strategies? Geographic information systems offer some scope for merging different data sources so that local assessments can be layered over city-wide assessments of vulnerability, capacity and hazard. This is useful for ground-truthing city-wide assessments which in rapidly expanding cities are difficult and costly to keep updated. A potential alternative and more process-oriented approach is to build local assessments into deliberative planning mechanisms such as community forums; here the focus is on building democratic structures in local governance as much as it is about direct outcomes for risk reduction.

One important experience in developing the information base for risk reduction is community-managed enumerations and surveys.[244] In many cities, federations of slum/shack dwellers and local NGOs have undertaken surveys and mapping of all informal settlements at a citywide scale – for instance in Johannesburg and Cape Town[245] in South Africa, in Kisumu[246] in Kenya and in Phnom Penh[247] in Cambodia. This has also been done for all of Karachi's informal settlements by the Pakistan NGO, the Orangi Pilot Project Research and Training Institute and this detailed mapping provided the basis for determining, designing and implementing infrastructure improvements.[248] The advantage of these initiatives is that they not only identify risk but also focus on populations that are particularly vulnerable. In many cities, the federations and their support NGOs have also undertaken surveys of vacant land to identify safe and appropriate sites for relocation, when in-situ upgrading is not possible.[249]

In addition, housing federations and their support NGOs have also undertaken many detailed household surveys in informal settlements – covering every household and producing very detailed maps showing plot boundaries and existing infrastructure provision. Obviously, this provides the information base needed for investment plans for infrastructure and upgrading housing – and often for plot regularization and provision to households of land tenure. These are often the first surveys, plans and maps ever produced for these informal settlements – even when such settlements have a significant proportion of a city's population. They have also provided the means by which the residents of these settlements and their community organizations have engaged with local governments in discussing development plans for their settlements[250] – for instance in Nairobi,[251] Dar es Salaam[252] and Mumbai.[253]

At the city scale, disaster-risk assessment methods have been developed. One example is the Holistic Vulnerability Index (HVI)[254] calculated only in relation to seismic risk. It measures disaster risk as the probability of a loss occurring as a consequence of a seismic hazard with a defined magnitude over a given time. It includes indicators for physical and social vulnerability, thus demonstrating to decision-

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[244] See http://www.sdinet.org/rituals/ritual2.htm

[245] Community Organization Urban Resource Centre (2005), *Profiles of Informal Settlements within the Johannesburg Metropole*, Community Organization Urban Resource Centre, Cape Town, 170 pages; CORC/Community Organization Resource Centre (2006), *Profiles of the Informal Settlements within Cape Town Metropole*, Community Organisation Resource Centre, Cape Town, 220 pages.

[246] Pamoja Trust (2006), *Social Economic Mapping In Kisumu*, report prepared for UN Habitat, Cities without Slums Kisumu Initiative, Pamoja Trust, Nairobi.

[247] ACHR (Asian Coalition for Housing Rights) (2004), "Negotiating the right to stay in the city", *Environment and Urbanization*, Vol. 16, No. 1, pages 9–26.

[248] Hasan, Arif (2006), "Orangi Pilot Project; the expansion of work beyond Orangi and the mapping of informal settlements and infrastructure", *Environment and Urbanization*, Vol. 18, No. 2, pages 451–480.

[249] Patel, Sheela and Diana Mitlin (2004), "Grassroots-driven development: The Alliance of SPARC, the National Slum Dwellers Federation and Mahila Milan" in Mitlin, Diana and David Satterthwaite (editors), *Empowering Squatter Citizen; Local Government, Civil Society and Urban Poverty Reduction*, Earthscan, London, pages 216–241. For one particular example, see Bolnick, Joel and Greg Van Rensburg (2005), "The Methodist Church's initiative to use its vacant land to support homeless people's housing and livelihoods in South Africa", *Environment and Urbanization*, Vol. 17, No. 1, pages 115–122.

[250] Patel, Sheela (2004), "Tools And Methods for Empowerment Developed by Slum and Pavement Dwellers' Federations In India", *PLA Notes* 50, IIED, London.

[251] Weru, Jane (2004), "Community federations and city upgrading: the work of Pamoja Trust and Muungano in Kenya", *Environment and Urbanization*, Vol. 16, No. 1, pages 47–62.

[252] Glockner, Heike, Meki Mkanga and Timothy Ndezi (2004), "Local empowerment through community mapping for water and sanitation in Dar es Salaam", *Environment and Urbanization*, Vol. 16, No. 1, pages 185–198.

[253] Patel, Sheela, Celine d'Cruz and Sundar Burra (2002), "Beyond evictions in a global city; people-managed resettlement in Mumbai", *Environment and Urbanization*, Vol. 14, No. 1, pages 159–172.

[254] Carreño, M.L., O.D. Cardona, A.H. Barbat (2007), "Urban seismic risk evaluation: a holistic approach", *Journal of Natural Hazards*, Vol. 40, No. 1, pages 137–172.

makers the need for work on both fronts. The index has been applied to various districts of Bogotá, Colombia, and results were considered in the preparation of the 2000 Urban Master Plan. Additional tools for comparing risk between cities have also been developed by the insurance industry, although these focus on insured and economic risk and so have only partial relevance to planning for adaptation to climate change in cities of Africa, Asia and Latin America and the Caribbean. For example, the Munich Re's Natural Hazards Risk Index for Megacities which has been applied to 50 cities identifies only one mega-city from low- and middle-income nations, Manila, in its ten cities most exposed to disaster risk.[255]

The background paper on India noted the serious challenge for public policy and mitigation management in addressing a complex of five major risk groups: temperature and precipitation variability; drought; flooding and extreme rainfall; cyclone and storm surge; and environmental health risks. It noted an important new method that can help in addressing these concerns: composite risk assessment and mitigation planning. "This enables a geographically explicit estimation of probabilistic hazard risk; vulnerability and the imputed composite multi-hazard economic risks. Risk prioritization by hazard, element at risk and location can thereafter be undertaken, assisting in creating evidence based investment, regional and urban development policies and building a bridge between public agencies, communities and the private sector."[256]

V. UNDERSTANDING SCALES FOR ACTION

Getting the needed scale of response

At the risk of over-repetition, it should be clear that the largest constraint on getting the needed scale of response is the incapacity and/or unwillingness of city and municipal governments to act appropriately. If city and municipal governments cannot or will not act to reduce the vulnerability of their low-income population to everyday environmental hazards and to disasters not related to climate change, and address backlogs in infrastructure and service provision, they are not likely to act on adaptation to climate change. It is also difficult to conceive of how they could do so, if much of the population within their jurisdiction is not served by infrastructure. This unwillingness or incapacity is not easily acted on. It is underpinned by a great range of factors, most of which are not easily addressed. This is a point that is perhaps still under-appreciated in discussions of adaptation. There is still a strong tendency among climate scientists to see solutions at scale achieved through much-increased internationally supported investment budgets for national adaptation plans and good "technical advice".

The different levels at which action is needed

While most adaptation in cities needs local knowledge and capacity, higher levels of government have critical roles in ensuring that city governments have this knowledge and capacity – and funding and expertise to draw on if needed. One area that needs addressing is the information base to encourage and support action. The density of weather-watch stations in Africa is eight times lower than the minimum level recommended by the World Meteorological Organization.[257] Many nations are unable even to monitor the climate, let alone forecast changes;[258] the same is also true for most urban centres. There is a similar dearth of systematic collection of data on hazard events and impacts from everyday to catastrophic events. This is not just a problem in African cities but also a major constraint on developing appropriate policy to support adaptation worldwide.

In Latin America, there has been progress in developing the needed information based at national level – for instance the increasingly reliable seasonal climate forecasts to understand and predict the El Niño and La Niña phenomena.[259] Improvements exist in climate monitoring and remote sensing, which provide better early warnings on complex climate-related hazards.[260] Different regional networks have been

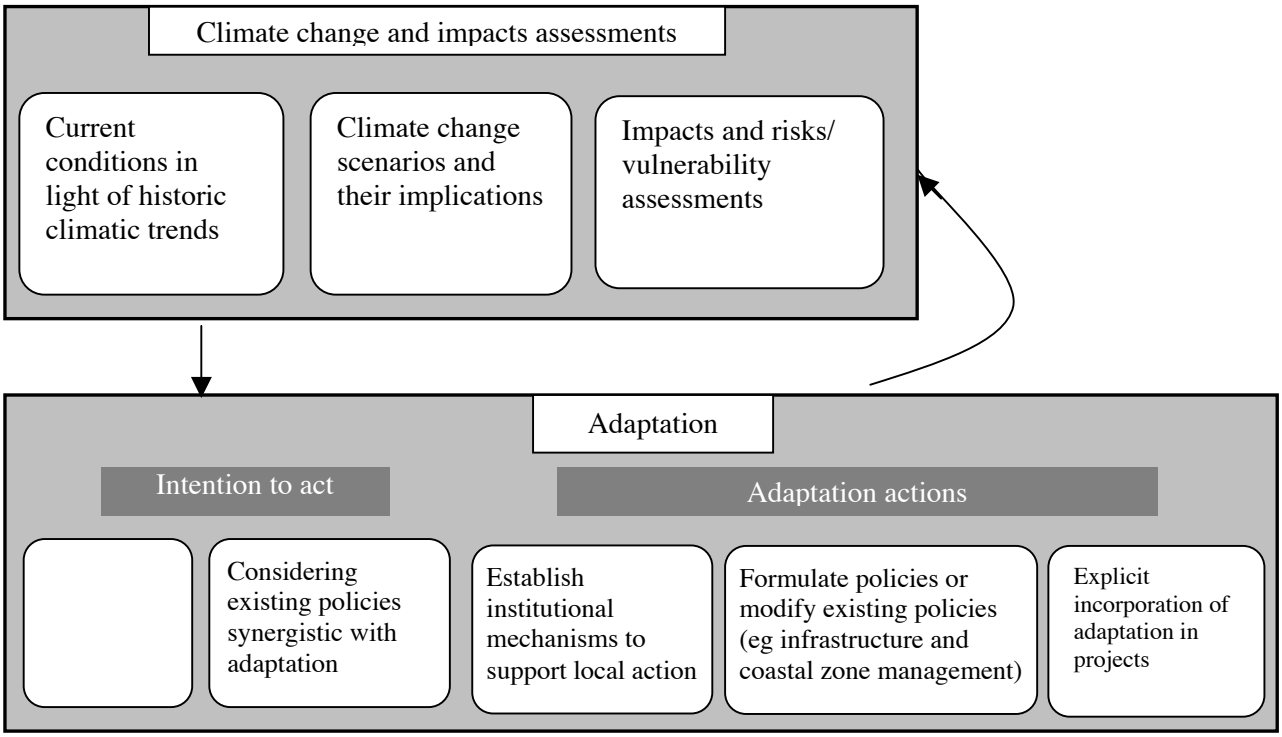
[255] Munich Re (2004), *Megacities-Megarisks: Trends and Challenges for Insurance and Risk Management*, Munich Re (accessed from http://www.munichre.com/publications/302–04271_en.pdf).
[256] Revi (2007), op. cit., page 10.
[257] Washington, R., M. Harrison, and D. Conway (2004), "African climate report: a report commissioned by the UK Government to review African climate science, policy and options for action", December.
[258] Stern (2007), op. cit.
[259] Magrin et al. (2007), op. cit.
[260] Adger, Agrawala, Mirza et al. (2007), op. cit.

established to predict seasonal climate and climate extremes but this work needs to be extended to support development within city governments of local knowledge and capacity.

Action at national level

A review of progress in OECD nations on adaptation to climate change produced a useful figure, showing some key stages in moving from assessing impacts to intention to act and finally implementing adaptation options (see Figure 3). It is interesting to note the lack of discussion in this document in regard to the relative roles of local and national governments and on what support local governments may need to act effectively. There is an assumption that a good national policy will result in action on the ground, including that by local governments. Perhaps this is valid for high-income nations but its validity is certainly much less so for most low- and middle-income nations. It may need innovation and leadership from local governments not only to demonstrate what is possible but also to help set or change national policies. It is also possible to view Figure 3 as a summary of what city governments must do, rather than national governments.

Figure 3: Moving from assessment to intention to act and finally adaptation actions



SOURCE: Based on Figure 6 in Gagnon-Lebrun, Frédéric and Shardul Agrawala (2006), Progress on Adaptation to Climate Change in Developed Countries; An Analysis of Broad Trends, ENV/EPOC/GSP(2006)1/FINAL, OECD, Paris, 59 pages.

The Stern report noted that, even in high-income nations, only a handful of governments are moving towards implementing adaptation initiatives.[261] An initial review of what governments in low- and middle-income nations are doing on adaptation produced the following tentative conclusions.

- Many governments are initiating or sponsoring studies of the likely impacts of climate change but most are made by natural scientists who lack knowledge, capacity and often interest in engaging with impacts on urban areas. This is the case even in nations where more than 90 per cent of the GDP is generated by urban-based enterprises and most of the people live and work in urban areas.

[261] Stern (2007), op. cit.

- Many (or possibly most) of these studies of climate-change impacts are funded by international agencies, and perhaps this diminishes the interest in them from national, city and local governments.
- There is an urgent need for locally made studies because of the extent to which local context shapes vulnerabilities and the nature of vulnerable groups and adaptation possibilities. The absence of a strong information base on what local impacts climate change is likely to bring is inhibiting this.

A review of available literature and specially commissioned papers on India, Chile and Argentina show that many central governments are beginning to do something about adaptation but this has yet to engage the interest of the larger, more powerful national ministries or agencies, or city or municipal governments. A case study of Durban is interesting for showing the importance of locally generated study of "impacts" rooted in local contexts and possibilities for getting the attention of city government. It is also interesting to see the difficulties that those in government working on environmental issues had in getting the attention of their colleagues; also worth noting is the extent to which recent storms in Durban helped to sensitize local politicians and civil servants.

Mexico: Interest in climate change in Mexico emerged during the 1990s at the federal level, with the launching of the country study. The country endorsed the Kyoto Protocol in 2001 under the principle of common but differentiated responsibility. In 2000, the federal government launched the National Strategy of Climatic Action, and in 2004 created the Mexican Committee on Projects for Reducing Emissions and Capturing Greenhouse Gases to participate in the Clean Development Mechanism. Yet, these unities lack influence over the key secretaries, ministries and offices that need to act for adaptation.

India:[262] The Indian government made a late start in engaging with questions of climate change. This is largely because of its pre-occupation with pressing poverty, economic and social development and political challenges in the post-Rio period, when climate change began creeping onto the global policy agenda of a few nations and multinational firms, and became an interest for an expanding community of researchers and international NGOs concerned with environment and development.

India has undertaken four national technical assessments of climate-change risks, impacts and mitigation options since 1992. These shared three common features: they were largely externally funded and driven; they were coordinated by the Ministry of Environment & Forests which is far from being the politically most powerful ministry of the central government; and they were primarily focused on the "science" of climate change driven strongly by the IPCC agenda and therefore weak in engaging with the complex nature and intensity of vulnerability in India, which is probably the most critical factor in risk mitigation.[263]

The great missed opportunity of the last 15 years was the joining-up of the climate-change adaptation and mitigation agendas with the rapid development of natural-hazard risk assessment, management and mitigation capacity after a series of devastating disasters in the 1990s and the early 2000s. A series of moderately successful post-disaster reconstruction and linked mitigation programmes, especially after the Orissa supercyclone (1999), the Kachchh earthquake (2001) and the Indian Ocean Tsunami (2004) have dramatically altered perceptions and the institutional and technical capacity to address vulnerability reduction and risk mitigation. The 2004 Indian Ocean Tsunami and the devastation it wrought along India's eastern coast also brought to the fore the need for the integrated management of India's coastal zone to balance concerns of environmental and biodiversity conservation, livelihood and economic development and risk mitigation. A series of Integrated Coastal Zone Management Plans are now in progress along with a review of the principles and norms by which the Coastal Regulation Zone needs to be managed. This will provide an important stepping-stone for a more evidence-based set of measures on climate mitigation and adaptation for coastal India.

[262] Revi (2007), op, cit.
[263] Revi, A. (2005), op. cit.

The other important post-2004 development is the reappearance of a significant public policy agenda on urban development, urban renewal and governance. The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was initiated in 2005 to target 60 of the largest and most important cities with a $10 billion challenge fund that addresses infrastructure development, urban poverty and improvements in urban governance. It is hoped that more rational urban infrastructure development with a strong pro-poor focus would help address some of the structural vulnerabilities of many million-cities and state capitals. But, as yet, there is no independent sub-component that addresses either urban vulnerability or risk mitigation, and no sign of a climate-change-related response.

An important post-1990 factor in Indian cities is the emergence of city-level political processes, community and people's movements, which contest from "below" for "space" for the poor within many cities. This has grown partially from a greater political consciousness following the devolution of political and administrative power to Urban Local Bodies by a Constitutional amendment in the 1990s. This has also encouraged greater NGO and judicial activism on a range of environmental questions, ranging from local greening and forest conservation to air and water pollution. This has had little impact on the most pressing environmental health concerns in cities that affect most of the low-income population. These currently fractured forces could, if adequately mobilized, provide a base for future city-wide Community Based Risk Mitigation (CBRM) efforts that are crucial to the success of risk mitigation and adaptation for climate change.

Chile:[264] There is a growing interest in Chile within government, among academics and within the media in climate change and related issues – but the information base is inadequate to encourage national and local governments to consider adaptation. The National Commission for the Environment (CONAMA) has the key role in regard to climate change, taking actions to comply with the UN Framework Convention on Climate Change (UNFCCC). Since 1998, CONAMA has been working on a National Action Plan on Climate Change, which is structured around adaptation, mitigation and the creation and reinforcement of national capacities.

In the National Strategy for Climate Change, approved in 2006, the specific objectives for adaptation are:

a. evaluation of the environmental, economic and social impacts of climate change;
b. definition of adaptation measures; and
c. implementation and follow-up of these measures.

After reviewing available literature and consulting the main stakeholders about adaptation, it seems that there is a good level of information related to the evaluation of environmental impacts. On the related economic and social impacts, however, no relevant information was identified.

Various studies of vulnerability to climate change and adaptation have been done. The first, in 1998, covered agriculture, water resources and forestry. The second was on coastal areas and fishing resources and focused on Concepcion, a coastal urban conglomerate with around one million inhabitants. It sought to value the costs of sea-level rise and is among the few documents that consider possible impacts at the urban level. The most recent official analysis is a *Study of the Climate Variability in Chile for the XXI Century*, specifically for the period 2071–2100. The analysis provides detailed information on the vulnerability of each of Chile's five main regions to climate-change impacts, especially changes in temperature, sea-level rise, precipitation, forestry and agriculture. It considers two possible emission scenarios: moderate and severe, as suggested by the IPCC. CONAMA suggests that the definition of adaptation, implementation and follow-up measures will be addressed once there is more information on social and economic vulnerability. Current studies on environmental impacts appear to be enough to start a process of awareness creation and institutional mainstreaming in the most vulnerable regions. Specific plans and actions to reduce vulnerability are, in general, absent and seem to be the next step for the government.

[264] This draws on Martínez, K., E. Claro and H. Blanco (2007), "Actions to reduce vulnerability to climate change impacts: the case of Chile", paper prepared for the Rockefeller Foundation's meeting on Building for Climate Change Resilience, Rides, Santiago, 9 pages. This was based on a review of available literature and discussions with key informants, including academics working on climate-change issues and personnel from the government and international agencies.

Concern about climate change has been growing within other institutions in Chile, as expressed by media coverage and the increasing number of studies and initiatives taking place. Many institutions such as universities, research institutions, NGOs and international organizations have been active in organizing workshops to discuss the vulnerability of the country and possible adaptation measures.[265] In addition, some ministries and public bodies related to the sectors potentially affected by climate change (energy, weather, agriculture, forestry and biodiversity) have developed programmes and studied initiatives that could reduce vulnerability.

CONAMA is aware that the longer the costs of adaptation are unknown, the higher the consequences and costs of inaction. But no government institutions see investment in adaptation measures and infrastructure as a priority. Some Latin American governments have been reporting to the UNFCCC on activities or pilot projects to reduce vulnerability but, as yet, the government of Chile has not done so. There is an urgent need to remedy the lack of information regarding adaptation costs and social and economic impact analysis. There are no concrete examples of on-going, planned government measures or investment projects (at the local or regional level) to address vulnerability. Much work needs to be done, particularly in developing social and economic impact studies, and involving regional and local actors in the preparation of the National Action Plan.

Argentina:[266] Climate change and its implications for some aspects of development in Argentina (especially agriculture) have received a lot of attention in the media and some attention from the national government and from academics and NGOs. But there is little detailed discussion of what is needed for adaptation, and little of the discussion on climate change considers the vulnerability of urban areas. The national government has signed key protocols and conventions and it participates in international meetings. It has created a Unit to deal with climate-change issues within the Secretary of Environment and Sustainable Development, and this has various national programmes – for instance on the impacts of climate change, reducing emissions, alternative energies, energy efficiency, bio-fuels, environmental education and national climate-change scenarios. But, as in many other nations, there is a need to translate the growing evidence showing what changes are required into the plans and investments of the key secretaries, ministries and offices that need to act for adaptation. In addition, in general, environmental issues have not got much attention from the government in the past; this is beginning to change as environmental issues begin to show up in local government agendas but these are local environmental concerns relating to (for instance) provision for water and sanitation or pollution control or disasters that have long been risks. Provincial and local governments have never shown much interest in addressing vulnerabilities to disasters; the government system has always reacted to disasters, never investing in the adaptations that would lessen their impact. This does not augur well for the kind of long-term investments and adaptations needed to reduce vulnerabilities related to climate change.

There is a group of academics, mostly from the natural sciences, engaged in studies of the impact of climate change on Argentina, within future scenarios. All agree that there will be effects due to climate change – and there is a growing body of work on the likely impacts of climate change. For the heavily populated coast, this means increased rainfall, changes in wind patterns and more floods. Floods in the Rio de la Plata affect large regions and are associated with storm surges; climate change with its combination of sea-level rise and more adverse weather conditions may increase the severity and/or frequency of floods. Many urban centres in Argentina, including large areas in and around the metropolitan area of Buenos Aires, are vulnerable to severe flooding and climate change is likely to make this worse. But the inadequacies in local government action to invest in the measures needed to reduce such floods (and these have long happened, unrelated to climate change) have long been evident. Much of the physical growth of Buenos Aires and of several other cities is over floodplains. The research and discussions and the media coverage of climate change have not produced the basis for government technicians and local governments to discuss what changes are needed. Climate change is not considered

[265] Two workshops organized by the National Ecological Institute, UNDP and GEF on “Climate Change, Disasters and Adaptation”, organized by the Ecological Politics Institute in December 2004 and May 2006 in Chile. Additionally, an international project (Canada–Chile) on institutional adaptation to Climate Change, focusing on dryland regions has been coordinated in Chile by University of La Serena (http://www.parc.ca/mcri/index.php).
[266] This is drawn from Hardoy and Pandiella (2007), op. cit.

in the 2006 Urban Environmental Plan of the city of Buenos Aires (so there is no mention of plans for adaptation) or of the 2003 Hydraulic Plan of the city.

Challenges of drawing up and implementing National Adaptation Programmes of Action (NAPAs)

Key challenges

The main concern expressed by NAPA teams has been how to secure funding for the activities they identified. Identifying key adaptation activities is only the first step towards helping poor countries and communities adapt to climate-change impacts. The NAPA teams were also concerned about how best to mainstream NAPA projects into national development plans and strategies.[267] "At present, the adaptation process is generally channelled through the UNFCCC focal points, which are normally based in Ministries of the Environment. Such ministries usually have limited influence with other line ministries and with the Ministry of Finance."[268] They also generally have limited influence over local governments, yet this is the level of government where most adaptation should be devised and implemented.

Adaptation to climate change has become an important priority in the international negotiations on climate change in recent years, but it has yet to become a major policy issue within most governments in low- and middle-income nations, and especially among the Least Developed Countries (LDCs), most of which are particularly vulnerable to the adverse impacts of climate change. Much more needs to be done in terms of "mainstreaming" adaptation to climate change within national policy-making processes[269] and putting in place the systems and structures that encourage and support locally-driven adaptation. Perhaps more to the point, unless adaptation is seen by national and city governments to be complementary to development agendas, it will not get considered.

Another key challenge is ensuring that NAPAs don't become just another policy document, with no translation into concrete support for adaptation among the world's poorest and most vulnerable communities.[270] "Countries are already bombarded with international obligations, which place considerable strain on already overloaded institutions with limited capacity, and which may well lead to duplication of effort and reduction in policy coherence."[271]

Lessons from NAPAs

The Annexe contains a summary of urban projects within the NAPAs. In general, the projects identified in the NAPAs submitted to date are of two types: sector-specific projects, which focus on water, agriculture and health; and non-sector-specific projects, which generally focus on broad cross-cutting themes such as information development. Most projects and actions are sector-specific and involve direct investment in adaptive actions.

In addition to direct investment, building capacity and mainstreaming adaptation into planning are considered high priorities. Relatively few projects are concerned with awareness, information or research. Lacking from the NAPA portfolio are institutional or structural reform or financial mechanisms. This may reflect the NAPA guidelines, which focus on urgent action rather than strategic development planning. The result is that projects are sectoral in focus without facilitating the significant structural and institutional reform required to mainstream climate change into national policy and planning and also support the needed adaptation capacity within local governments. Actions for reducing conflict and empowering disadvantaged communities are also not widely reflected in the NAPAs.

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[267] Osman-Elasha, B. and T. Downing (2007), Lessons Learned in Preparing National Adaptation Programmes of Action in Eastern and Southern Africa, unpublished paper, Stockholm Environment Institute.
[268] Stern (2007), op. cit., page 498.
[269] Huq, S. A. Rahman, M. Konate, Y. Sokona and H. Reid (2003), *Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCs)*, IIED, London.
[270] Osman-Elasha and Downing (2007), op. cit.
[271] Dalal-Clayton, B. (2003), "The MDGs and sustainable development: the need for a strategic approach" in Satterthwaite, D. (editor), *The Millennium Development Goals and Local Processes: Hitting the Target or Missing the Point*, IIED, London, pages 73–91.

The NAPA process contains many inherent biases. For example, it places less emphasis on the urban poor than on the rural poor, and neglects vulnerable social groups such as women and refugees.[272] The lack of community-based adaptation plans may be inherent in the agenda of the line ministries that often lead NAPA projects. And the relative lack of urban projects reflects the fact that Least Developed Countries do not have ministries that focus on urban issues. Perhaps it also reflects more fundamental biases against "urban" initiatives from civil servants and international agencies.

The urban initiatives described in the Annexe that are within the NAPAs cover a wide range of initiatives – for instance addressing particular risks (e.g. sea-level rise, river flooding, increased risks from malaria, more constrained freshwater supplies), building a stronger local information base of risks and vulnerabilities, improved disaster preparedness (including early warning systems) and better-quality, cheaper building materials. But most also include strengthening local capacity to plan and act – including changing local building and infrastructure standards and land-use plans.

This is a reminder of the extent to which NAPAs (National Adaptation Programmes of Action) need to built from city-focused CAPAs and local-focused LAPAs. Risks and vulnerabilities for all aspects of climate change are shaped by local contexts and much influenced by what local governments do or do not do. In the end, almost all adaptation is local. To be effective, it needs strong local knowledge and strong local adaptive capacity. Certainly for urban areas, there need to be City Adaptation Programmes of Action and, very often, smaller scale Local Adaptation Programmes for Action – especially for the settlements or areas most at risk. These, in turn, can also promote learning and innovation on how public policies and investments can work best with community-based adaptation. They also provide the practical experience on which NAPAs can be much improved.

Long-term changes in urban centres to reduce risks

So what long-term perspectives can guide settlement and urban development away from the urban centres or zones most at risk from storms and floods without threatening a nation's economic success? One of the most important is removing a key constraint on new investments away from cities on the coast – the weakness of local governments in urban centres or zones in less risky locations. More effective city and municipal governments in urban centres or zones outside the more risky locations will allow these locations to compete for new investments – and this has been a factor in developing urban systems less dominated by the primate city in many middle-income nations such as Brazil and Mexico. Among the many new economic activities currently concentrating in coastal locations at risk from storms and sea-level rise, a significant proportion do not require a coastal location but are concentrating there because of other supporting factors – for instance good infrastructure and services and easy access to government (perhaps an important source of business). This is obviously far more amenable to change than businesses (and workforces) that concentrate in coasts because of (for instance) port activities, fishing and coastal tourism. It is also likely that insurance cover will influence spatial locations for businesses and home-owners able to afford insurance, as the costs of insurance rises in locations where the frequency and intensity of storms and floods is increasing or likely to increase, and it may be that insurance cover will not be available in increasing numbers of coastal locations.

There is also the dramatic difference in the speed with which climate change is changing risk maps and the speed of adaptation. The speed with which city systems change to reflect the new "risk map" from climate change is likely to be slow, in relation to how rapidly the map is likely to change – especially if no global agreements are in place within the next few years to halt and then reduce global greenhouse-gas emissions. Part of this is because powerful economic and political interests want "their city" to continue attracting new investment. Large cities, once developed, acquire a capacity to remain as cities, even as their economic base declines. There are surprisingly few "great cities" from history that aren't still cities (even if their relative importance may have changed). Did the obvious and well-documented risk that New Orleans faced before Katrina actually cause many enterprises to move? New Orleans also faced an additional difficulty in that a high proportion of its economic base is related to its historic city and its rich culture, which cannot be moved. Venice is at high risk from sea-level rise and storms – but

[272] Osman-Elasha and Downing (2007), op. cit.

Venice cannot be "moved". Nor can Alexandria. Many of the sites most at risk from sea-level rise in many coastal cities are also among the most desirable residential areas and areas for popular recreation.

The political economy of any city influences what is done and what is likely to be done to reduce risks from climate-change-related impacts. A city as wealthy and successful as Mumbai has the resources that could have done far more to reduce risks from flooding (including better drains, better garbage-collection systems, and ensuring that poorer groups could find land for housing that was not at high risk from flooding). Why this was not done needs exploring. In part, it is because most of the risks from flooding are borne by lower-income groups. But cities such as Mumbai can invest in protection against floods and sea-level rise in ways that have strong "co-benefits" with development, as this also improves the homes and neighbourhoods of the millions of low-income households. They can greatly reduce risks by ensuring that low-income households can find and afford housing or land on which they can build in sites less at risk from flooding. Or the city can ensure that its investments do exactly the opposite, as informal settlements at risk of flooding are bulldozed with no measures taken to provide their inhabitants with alternative housing. Or if some provision is made for re-housing, this further impoverishes those forced to move as they are dumped in distant locations, far from their sources of livelihoods and social networks. As the risks facing so many major coastal cities in Africa, Asia and Latin America and the Caribbean become evident, one of the greatest worries is that this will draw attention and investment away from the unfulfilled development needs.

Typical adaptation measures outlined in the background paper on India have a wider relevance:

- relocation of particular settlements within urban centres out of highly vulnerable areas, especially the inter-tidal zone, riverine and low-lying areas;
- changes in city economic structure to shift out of sensitive economic activities, and changes in systems of governance to enable more rapid response to climate-change risk within the public and private sectors, using a mix of planning, market and financial instruments;
- moving a particular section of a city or the whole city to a new location – this would be unprecedented except for in relation to reservoir submergence in independent India (and hence would not be an economic but a political issue).

Decentralization

It is difficult to see city governments acquiring the needed competence and capacity to act (and to do so in ways that benefit poorer groups too) without support from higher levels of government. Brazil provides an interesting example of a nation where major developments have been achieved in an urban reform process since the promulgation of the 1988 Federal Constitution. These include the 2001 City Statute and the creation of the Ministry of Cities and the National Council of Cities in 2003. While recognizing the limitations in these innovations and the many issues that still need to be addressed, this is an important example of a national government striving to provide city governments with the legal and institutional base they need to be more effective and more accountable to their citizens. Without this, it will not be possible to reverse the spatial and social exclusion that has characterized most urban development in Brazil in recent decades.[273] And, without this, it will also not be possible for most city-governments to be effective in reducing risks associated with climate change in ways that also benefit poorer groups.

Most city and municipal governments get a very small proportion of the national investment budget, relative to the contribution of their cities and urban centres to GDP. For instance, in Peru, the national government transfers only 5 per cent of the national budget to the 2000-plus local governments.[274] In Mexico, there is a very large disparity between the fiscal capacity of the federal government and of the states and municipalities; the federal government gets close to three-quarters of all tax revenues while the states and municipalities get only 4.5 per cent.[275]

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[273] Fernandes, Edesio (2007), "Implementing the urban reform agenda in Brazil", *Environment and Urbanization*, Vol. 19, No. 1, pages 177–189.
[274] Diaz Palacios and Miranda (2005), op. cit.
[275] Romero Lankao (2007), op. cit.

Costs of adaptation

Introduction

"Only a few credible estimates are now available of the costs of adaptation in developing countries, and these are highly speculative. In a world of rapid climate change, it is increasingly difficult to extrapolate future impacts from past patterns, so historical records are no longer reliable guides. Furthermore, the discussion above has shown that conceptually this is a difficult calculation to solve: adaptation is so broad and cross-cutting – affecting economic, social and environmental conditions and vice versa – that it is difficult to attribute costs clearly and separately from those of general development finance. Adaptation should be undertaken at many levels at the same time, including at the household/community level and many of these initiatives will be self-funded."[276]

Even when impacts of climate change are not yet discernible, scenarios of future impacts may already be of sufficient concern to justify building some adaptation responses into planning. In some cases it could be more cost-effective to implement adaptation measures early on, particularly for infrastructure with long economic life.[277] When reviewing available literature, there were various studies suggesting that the cost of adaptation to climate change, at least in the next few decades, is not very great in relation to nations' GDP – but this is mostly in wealthy nations, where there is already the infrastructure, services and good-quality building stock "to adapt", and much greater investment and management capacities among local governments. If the cost of removing the backlog on basic infrastructure provision and in strengthening deficient buildings that will be needed for adaptation in less wealthy nations could be factored in, the costs would increase dramatically.

However, there is still reluctance among climate-change specialists to recognize this backlog in basic infrastructure and the deficiencies in institutional or governance structures that greatly limit effective adaptation. There is also little recognition of the vulnerability of large sections of the urban (and rural) population to extreme weather events and climate variability (outside climate change), and how this greatly exacerbates their vulnerability to many of the direct and indirect impacts of climate change.

Adaptation to sea-level rise

Adaptation to sea-level rise can include building coastal defences, realigning coastal defences by relocation landwards, abandoning coastal areas that are difficult or expensive to protect, reducing energy of near-shore waves and currents (through various measures, including beach nourishment, offshore barriers and energy converters) and coastal morphological management; it can also include modifying existing exposed settlements and infrastructure.[278] General cost estimates are very difficult to make, and vary greatly from location to location, and it is not possible to extrapolate costs of different elements (e.g. dike building). But many estimates have been made suggesting that coastal protection can reduce substantially the threat imposed by sea-level rise at a relatively low cost (for sea-level rise of 1 metre). Studies showing that coastal adaptation could reduce the number of people at risk from flooding (i.e. the number of people living in risk areas multiplied by the probability of flooding) by almost 90 per cent at an annual cost of around 0.06 per cent of GDP. The Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report examined adaptation costs but was unable to come to an aggregate figure for costs of adaptation globally. The costs for coastal protection have been estimated at over US$1,000 billion against a 1-metre sea-level rise.[279] But this estimate is acknowledged to be at best an informed guess. Another source noted that the protection costs of a 1-metre sea level rise could be more than several per cent of GDP for the most vulnerable nations and this would only cover the costs of managing land loss from permanent inundation and not the costs of protection to deal with episodic flooding (which could cause damages an order of magnitude greater).[280]

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[276] Stern (2007), op. cit., pages 501–502.
[277] Shukla, P.R., M. Kapshe and A. Garg (2004): *Development and Climate: Impacts and Adaptation for Infrastructure Assets in India*, ENV/EPOC/GS/FD/RD(2004)3/FINAL, OECD, Paris, 38 pages .
[278] Bosello et al, (2007), op. cit.
[279] Tol, R.S.J. (2002), "Estimates of the damage costs of climate change, Part 1: benchmark estimates", *Environmental and Resource Economics*, Vol, 21, pages 47-73 quoted in Adger, Agrawala, Mirza et al. op cit.
[280] Stern (2007), op. cit.

There are some estimates for low- and middle-income nations – for instance one study suggested that the cost of coastal protection for a 1m sea-level rise would range from a minimum of 0.01 per cent of GDP per year in Latin America to a maximum of 0.2 per cent of GDP per year for China.[281] Direct protection costs against 0.13m sea-level rise in 2030 is much smaller – from 0.001 per cent of GDP in Latin America to 0.035 per cent of GDP in India.[282] Other studies suggest that "high levels of coastal protection" are possible (for instance more than 70 per cent of the threatened coast) but the usefulness of such calculations might be in doubt if the 20–30 per cent of the coast that is not easily protected included most of the major cities. Another study looking at the direct cost of coastal protection, of fixed capital and land lost, suggested that a scenario of optimal protection against a sea-level rise of 50cm by 2100 would involve costs of 0.1 per cent of total expenditures in 1990 for East Asia, 0.07 per cent for South-east Asia and 0.05 per cent in "the rest of the world".[283]

However, some other studies suggest that the cost of protecting cities in low- and middle-income nations most at risk from sea-level rise "is not worth the cost"; for instance, the benefit–cost ratio for the vulnerable coastline of Dar es Salaam in terms of monetized avoided-damage–cost of the intervention for a sea-level rise of 0.3–1 metre was less than 0.2 – whereas for protecting the coastlines of Poland and Uruguay, the cities of Tallin and Parnu (in Estonia) and the Zhujian Delta in China this ratio was between 2.6 and 20.[284] But Dar es Salaam is central to the economy and future economic prospects of Tanzania; it includes its largest concentration by far of industry and services and its major port and airport. Studies looking at the economic efficiency of coastal protection suggested that for Senegal, "important area protection" can be a cost-efficient strategy– so for Senegal's current and future development prospects, one hopes that Dakar is within this area; this same study suggested that important area protection would not be cost-efficient for Uruguay or Venezuela.[285]

There is a need for greater clarity on this. Economic analyses may suggest that cities such as Dar es Salaam (or perhaps Montevideo in Uruguay) are not viable because of being on the coast and very vulnerable to flooding and sea-level rise, and the investments needed to protect them from floods and storm surges likely in the next 50–100 years are far beyond the likely investment capacity. But these cities are so central to the current and future development prospects of these nations and to the well-being of large sections of their population; they also contain most of the asset bases for large sections of the population. And these cities are being threatened by climate change to which their populations (or the populations within these nations) contributed very little. This raises moral issues to which this paper will return. Similarly, it is no doubt correct to suggest that for some countries, the efficient level of coastal protection can be low or even zero,[286] but this suggests that there will be very large adaptation costs or countries with much of their coastal area beyond any realistic possibility of adaptation – and these are almost always nations which have contributed and currently contribute very little to greenhouse-gas emissions. Here too there are moral issues that cannot be buried in aggregate statistics showing low adaptation costs. In addition, what appears as a relatively small cost in relation to a continent's GDP can hide very large adaptation costs for particular cities.[287]

Papers discussing the costs of adaptation can recommend that these should include not only the direct costs of implementing the adaptation but also the costs of enhancing adaptive capacity (for instance, of managerial capacity and other services) and the transition costs.[288] This is correct – but the difficulty is

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[281] Deke, O., K.G. Hooss, C. Kasten, G. Klepper and K. Springer (2001), *Economic Impact of Climate Change: Simulations with a Regionalized Climate-Economy Model*, Kiel Institute of World Economics, Kiel, 1,065 pages.
[282] Deke et al. (2001), op. cit.
[283] Darwin, R. and R.S.J. Tol (2001), "Estimates of the economic effects of sea level rise", *Environmental and Resource Economics,* Vol. 19, pages 113–129.
[284] Smith, J.B. and Lazo, J.K. (2001), "A summary of climate change impact assessments from the US Country Studies Programme", *Climatic Change,* Vol. 50, pages 1–29, quoted in Bosello et al. (2007), op. cit.
[285] Volonte, C.R. and R.J. Nicholls (1995), "Uruguay and sea level rise and: potential impacts and responses", *Journal of Coastal Research*, Vol. 14, pages 262–284; Volonte, C.R. and J. Arismendi, (1995), "Sea level rise and Venezuela: potential impacts and responses", *Journal of Coastal Research*, Vol. 14, pages 285–302, quoted in Bosello et al. (2007), op. cit.
[286] Bosello et al. (2007), op. cit.
[287] Wilbanks, Romero Lankao et al., (2007), op. cit.
[288] Bosello et al. (2007), op. cit.

that, in many nations, the political possibilities of this happening are very limited; this is not just an issue of "costs".

Adaptation costs, with a focus on infrastructure and buildings

Three sources give rather general cost-estimates for adaptation. The first examines high-income nations: the additional costs of making new infrastructure and buildings more resilient to climate change in OECD countries. This could range from $15 –$150 billion each year (0.05–0.5 per cent of GDP) with higher costs possible with the prospect of higher temperatures in the future. This assumes that additional costs of 1–10 per cent of the total invested in construction each year are required to make new buildings and infrastructure more resilient to climate change.[289] But this is not a methodology that can be applied in most low- and middle-income nations. To arrive at such an estimate, it is necessary to know the total investments in construction. There is very little data on this in low- and middle-income nations. Even the estimates that exist are likely to be misleading for two reasons. First, there are the (often very large) deficiencies and backlogs in infrastructure investments and deficiencies in the building stock. How can an estimate be arrived at for "adaptation" for infrastructure that does not exist? Second, official construction-investment statistics rarely consider the investments made by households and community organizations, even when (as is often the case) these are responsible for most new housing and most housing improvement.

The second source for general cost estimates comes from the World Bank, which has estimated the added costs for adaptation to climate change needed for aid flows ($1–4 billion a year), foreign direct investment ($1–4 billion a year) and gross domestic investment ($2–30 billion a year). This means total adaptation finance per year of $4–37 billion.[290] This includes only the cost of adapting new investments to protect them from climate-change risks, and there will be major impacts even with adaptation.[291] This also takes no account of the cost of providing infrastructure to all the locations that have very deficient or no infrastructure. It does not include reducing exposure to current climate-change risks. Since this is only the cost to governments, donors and foreign investors of climate-proofing their new planned programmes and investments, it represents a fraction of the needed measures.

The third source is the UNFCCC – for instance in the recently published UNFCCC background paper, *Analysis of Existing and Planned Investment and Financial Flows Relevant to the Development of Effective and Appropriate International Response to Climate Change*.[292] But its estimates for infrastructure are based on the cost of adapting existing infrastructure. The paper assumes that it is valid to convert "adaptation needs" into simple funding totals as if it is a lack of funding that explains the lack of adaptation capacity. No account is taken of the very large deficit in basic infrastructure. Even if the funding needed for adaptation was available, the necessary institutional capacity does not exist in most urban centres in low- and middle-income nations. There is also little recognition of the vulnerability of large sections of the urban (and rural) population to extreme weather events and climate variability (outside climate change) and how this greatly exacerbates their vulnerability to many of the direct and indirect impacts of climate change.

Thus, the whole basis for estimating the investment needed to adapt infrastructure is based on a questionable premise – that this can be costed by considering the cost of adapting existing infrastructure alone. No account is taken of the very large deficit in basic infrastructure. You cannot estimate the cost of the infrastructure needed for adaptation unless you consider the cost of addressing this deficit. This helps to explain why the UNFCCC paper's conclusions suggest that most of the investment needed for infrastructure is to adapt new infrastructure in high-income nations. That report also fails to come to terms with the very considerable diversity within what it terms "developing nations" in the adaptation capacity, including the extent to which this can be funded with domestic resources. It is not appropriate

[289] Stern (2007), op. cit.
[290] World Bank (2006), *Clean Energy and Development: Towards an Investment Framework*, Annex K, Washington, DC, World Bank, quoted in Stern (2007), op. cit. Note some disparities between the figures in Stern and the figures in the original document.
[291] Stern (2007), op. cit.
[292] UNFCCC (2007), Analysis of Existing and Planned Investment and Financial Flows Relevant to the Development of Effective and Appropriate International Response to Climate Change, background paper, UNFCCC, Berlin.

to generalize for all such nations. By doing so, the report also obscures the many nations that have very limited adaptation capacity. The UNFCCC report also makes no attempt to review where infrastructure investment is going within low- and middle-income nations, which would reveal how many nations get very little official development assistance for infrastructure.

There are some estimates of adaptation costs for certain cities in high-income nations. These are worth reviewing because they suggest that cost-estimates based on "real adaptation plans" for particular cities and localities will produce very different estimates for adaptation costs, compared to the OECD and World Bank estimates.

- In **New Orleans,** in the early stages of rebuilding, state officials suggested that the cost of providing the city with protection from a category 5 hurricane was about $32 billion.[293]
- For **London**, the increased cost of maintaining flood defences over 100 years because of climate change was estimated at $3–6 billion.[294]
- **Venice**: A $2.6 billion scheme to protect the city from rising tides is being implemented, but the current design is able to cope with only around 20cm further sea-level rise.[295]

These three cities have basic infrastructure in place serving all households and businesses, and a building stock subject to regulations on safety. If the adaptation costs for urban centres in low- and middle-income nations have to include the costs of remedying their infrastructure deficiencies – for instance in water supply and sanitation systems, all-weather roads and storm and surface drains – the costs are likely to be far higher than those implied by the World Bank. There are hundreds of large cities (most on the coast) and tens of thousands of smaller urban centres without basic infrastructure and lacking local governments with the capacity to remedy these deficiencies. It is worth recalling the examples of major cities with high vulnerability to storms and sea-level rise described above in Section III.

Two case studies of particular cities do give some idea of adaptation costs.

- Massawa (Mits'iwa) is the main port in Eritrea, with a population of around 23,000 in 2002. It is vulnerable to a sea-level rise of 0.5–1.0 metre since most parts are of the city are less than 1 metre above sea level. A 0.5m rise in sea level would submerge infrastructure and other economic installations to a total value of over US$250 million.[296]
- La Ceiba (Honduras) has a population of over 100,000 inhabitants. It is on the floodplain between the Caribbean sea and a mountain range; the Cangrejal river drains from the mountains and runs next to the city – and flooding is routine because of no storm-water drainage system. Occasional major flooding occurs from heavy rainfall events and hurricanes. In considering the design of an urban drainage system, climate change could lead to considerably more flooding from more intense precipitation. The cost of an enhanced urban drainage system able to cope with the estimated increased risks from climate change over the next 50 years would be more than a third higher than the cost of a system appropriate to the current climate.[297]

There are estimates available for the cost of addressing deficiencies in infrastructure and services for all low- and middle-income nations – and sometimes these are sufficiently disaggregated to allow some discussion of what proportion might be needed for urban areas (and one set of estimates was specifically for "slums and squatter settlements" in urban areas). These suggest that hundreds of billions of dollars are needed to address existing deficiencies in infrastructure and services. But before presenting these figures, some words of caution are needed. Estimates vary greatly for the cost of needed infrastructure and building modification, and for the possible role of international development assistance. This is illustrated by the different costings attached to a programme to improve and upgrade sewers and storm drains in Karachi. One set of estimates, prepared by the Asian Development Bank, suggested a total cost

[293] Hallegatte, S. (2006), "A cost-benefit analysis of the New Orleans flood protection system", (Regulatory Analysis 06–02), AEI-Brookings Joint Center for Regulatory Studies, Washington, DC quoted in Stern (2007), op. cit.
[294] Environment Agency (2005), "Evidence to the Stern Review on the economics of climate change", reported in Stern (2007), op. cit.
[295] Nosengo, N. (2003), "Save our city!", *Nature*, Vol. 424, pages 608–609, quoted in Stern (2007), op. cit.
[296] State of Eritrea (2001), Eritrea's Initial National Communication under the United Nations Framework Convention on Climate Change (UNFCCC).
[297] Stratus Consulting Inc. (2006), *Honduras Pilot Study Report: Climate Change and Coastal Resources and Flood Planning in La Ceiba*, final report, prepared for: US Agency for International Development.

of around US$100 million, with $80 million of this to be funded by a loan from this bank. A local NGO that had been working for 20 years in supporting community-based construction and management of sewers and drains came up with an alternative plan that they claimed was not only far more effective (it built on existing sewers and drainage systems constructed by households and communities rather than seeking to replace them) but also far cheaper.

In the end, the local plan was chosen – and implemented, at a fifth of the cost of the original proposal and with no need for the international loan.[298] In Karachi, the work of this local NGO (The Orangi-Pilot Project Research and Training Institute) and of the Urban Resource Centre has highlighted how other internationally funded infrastructure projects are generally far more expensive than those funded by local sources. In part, this is because banks have little interest in keeping down loan costs, and their functioning depends on large loan portfolios. If the Asian Development Bank proposal for Karachi had been taken as an example of needed adaptation, it would imply the need for very large-scale funding by international agencies. If the initiative finally implemented serves as the example of needed adaptation, it needed no external funding – and no loan (and so no loan repayment required from the Pakistan government).

This is not an isolated example; there are many other examples of infrastructure investment, service improvement and upgrading building stock that are increasing the resilience of cities to climate change in ways that serve poorer groups and that are largely or entirely funded by local sources – typically a mix of individual and household contributions and government funding. One good example of this has been mentioned above – the nation-wide slum and squatter upgrading programme in Thailand which is almost entirely funded by a combination of government and community/household resources.[299] Three further examples will be given here of estimates for addressing different aspects of the backlog in infrastructure provision. Two estimates are drawn from plans to meet the Millennium Development Goals, but the first is the cost of remedying existing deficiencies in provision for water, sanitation and drainage in urban areas.

For Africa, assume that there are 30 million urban dwellings lacking provision for water and sanitation[300] and that the average cost of providing water and sanitation is $200–$400 per household.[301] Then assume that total costs for the whole system are twice the cost of this provision (for instance to cover water abstraction and treatment, and trunk infrastructure) and the total cost for African urban areas would be US$6–12 billion. For Asia, assume there are 150 million urban dwellings lacking provision for water and sanitation and that costs per household are the same, so total costs for Asian urban areas would be US$ 30–60 billion For Latin America and the Caribbean, the total cost would be about the same as for Africa. So at least $42 billion would be required for all three regions. Obviously, the proportion of this that could be funded by local and national governments would differ greatly between these regions – and nations.

Among some middle-income nations, there are also major improvements in provision that are largely funded without external assistance – for instance the expansion in provision in Brazil[302] and Mexico.[303] There are also good examples of high-quality provision that are cheaper than $200 per household for water and sanitation but these rarely include the cost of the trunk infrastructure (the water mains and the trunk drains) which these need. The innovations in improving provision for sewers and drains in Karachi at low cost, and in ways that reached large sections of the low-income population (and the role of civil

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[298] Hasan, Arif (1999), *Understanding Karachi: Planning and Reform for the Future*, City Press, Karachi, 171 pages; Hasan (2006), op. cit.; Hasan, Arif (2007), "The Urban Resource Centre, Karachi", *Environment and Urbanization*, Vol. 19, No. 1, pages 275–292.

[299] Boonyabancha (2005), op. cit.

[300] UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.

[301] It is impossible to estimate the real costs – in part because they will vary so much from place to place, and indeed within each place, depending on who designs and implements. A "high-income"-nation solution with a 24-hour service of piped water supplies to drinkable standards and a flush toilet is generally much more than this; some innovative programmes that have provided good-quality water and sanitation are less than this.

[302] Heller, Léo (2006), Access to Water Supply and Sanitation in Brazil: Historical and Current Reflections; Future Perspectives, background paper for the 2006 edition of the Human Development Report, 51 pages.

[303] UN Habitat (2006), op. cit.

society in this), are also worth reviewing as an example of an alternative approach.[304] Box 14 gives estimates for the costs of adaptation for urban and rural water supplies in Africa. When comparing this estimate to that given above, note should be made that this is the estimated cost of adaptation, *not* the cost of making up deficiencies in provision. Again, these suggest high costs for adaptation.

Box 14: Estimates for the potential cost implications of climate change for cities in Africa

If we assume that climate change will mean a 30 per cent reduction in average stream flow with the unit cost of water going up more than 40 per cent. Also, that the overall cost of waste water treatment will double and that reduced stream flows will also mean a 30 per cent reduction in hydro-electric production..

Applying these assumptions, and using unit costs derived from actual project experience, the costs of adapting existing urban water infrastructure in Africa have been estimated at US$1.05–2.65 billion annually. This includes urban water storage, wastewater treatment and electricity generation, but not the cost of rehabilitating deficient infrastructure

The costs of new development are also likely to rise by US$1–2.55 billion a year. In general, the marginal unit cost of water-resources development for water supply to urban areas increases with each new increment of supply. It is therefore conservative to assume that the costs of adapting to climate change for new developments will be similar to those for existing systems.

There will be additional costs incurred in the construction of roads and storm drainage, from the loss of use of land threatened by floods, and for additional flood protection for existing settlements. These and other indirect effects are site-specific and less easy to cost on a regional level.

SOURCE: Muller, Mike (2007), "Adapting to climate change: water management for urban resilience ", *Environment and Urbanization*, Vol. 19, No 1, pages 99–113.

The second set of estimates comes from the Millennium Assessment which made some estimates for investment needs per person for meeting the Millennium Development Goals in five nations (Table 11). This included more disaggregation than most estimates – and of particular interest for this report are the estimates for addressing deficiencies in provision of water supply and sanitation, improving the lives of slum dwellers and health care.[305] The investment needs for water and sanitation were put at between $47 and $77 per person over a ten-year period. If these are representative of the needed investment in all low- and middle-income nations, then the total investments needed are huge: applying a need for $50 per person over a ten-year period to the population in low- and middle-income nations produces a total of $300 billion (or $30 billion a year) for rural and urban areas. Good provision for water and sanitation is more expensive in urban areas than in rural areas – but there are economies of scale and proximity and often greater capacity to pay for good-quality systems. But clearly, based on these figures, at least $150–200 billion would be needed for urban water and sanitation.

This same source suggests a need for around $30 per person over the ten years for improving the lives of slum dwellers. If applied to the 900 million people who were living in "slums" in 2000, this would imply a need for around $27 billion. Provision for roads costs between $103 and $217 per person over this ten-year period – so if we assume $100 per person for all low- and middle-income nations, this implies around $600 billion over ten years (covering rural and urban populations) – and a similar amount is needed for what Table 11 lists as "Other", including large infrastructure projects, higher education and national research.

The financing gap (the difference between total investment needs to meet the Millennium Development Goals and domestic resource mobilization from households and governments) is around $600 per person for these five nations. If this average were applied only to the least developed nations, this would still mean $480 billion over ten years. This same source does estimate the MDG finance gap for all low- and middle-income nations – at $73 billion in 2006, rising to $135 billion in 2015. The usefulness of this

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[304] Hasan (2006), op. cit.

[305] Sachs, Jeffrey D. and the UN Millennium Project (2005), *Investing in Development; A Practical Plan to Achieve the Millennium Development Goals*, Earthscan, London and Sterling, VA, 224 pages.

exercise in costing can be questioned – especially in its implication that it is a lack of international funding that is the main constraint on meeting the Millennium Development Goals, ignoring political and institutional constraints. But it does highlight the high monetary cost of addressing current deficiencies in infrastructure and services.

Table 11: Examples of average investments needed per person over a ten-year period (2006 to 2015) to meet the Millennium Development Goals (US$)

	Bangladesh	Cambodia	Ghana	Tanzania	Uganda
Hunger	47	83	67	83	60
Education	177	187	193	137	153
Gender equality	27	27	27	27	27
Health	207	223	253	350	333
Water and sanitation	50	53	77	70	47
Improving the lives of slum dwellers	30	33	23	33	23
Energy	193	150	153	157	117
Roads	213	213	103	217	200
Other, including large infrastructure projects, higher education and national research	100	100	100	100	100
TOTAL (US$)	1,047	1,067	993	1,147	1,060
MDG finance gap	587	617	597	717	590
Shortfall of ODA for direct MDG support over 2002 level	573	437	403	563	470

NOTE: This is drawn from Sachs, Jeffrey D. and the UN Millennium Project (2005), *Investing in Development; A Practical Plan to Achieve the Millennium Development Goals*, Earthscan, London and Sterling, VA, 224 pages, but the original listed figures for individual years for 2006, 2010 and 2015. To get the figures above, an average was taken of these three annual figures and multiplied by 10.

A third set of estimates comes from the Millennium Assessment's Taskforce on Improving the Lives of Slum Dwellers[306] which, perhaps surprisingly, was not used in the synthesis volume. These estimates are interesting for this report because they focused specifically on "slums and squatter settlements". The costs per person for "slum and squatter upgrading" vary greatly from initiative to initiative – from under US$100 to over US$1,000, so it is difficult to estimate the cost of upgrading per region and for all low- and middle-income nations. But this taskforce produced some estimates for the cost of upgrading "slums and squatter settlements" and for building good-quality alternatives to these for expanding urban populations up to 2020. These are also unusual in that they consider the cost of the supporting infrastructure required. This report suggests that the average cost per person for upgrading was U$665 – although this cost varied considerably by region (Table 12). This estimate included funding for land purchase and transfer, housing improvement, network infrastructure, bulk infrastructure, schools and health clinics, community facilities, planning and oversight, and community capacity building. To achieve the Millennium Development Goal target of significantly improving the lives of 100 million slum dwellers, this would cost US$66.5 billion.[307] Obviously, if this were to be more ambitious and significantly improve the lives of all slum dwellers, around ten times this amount would be needed. This Taskforce suggested that if 30 per cent of these investments could be recovered through small loans and 10 per cent was contributed by residents themselves, about $39.9 billion would have to be provided in the form of subsidies over the period 2005–20.

[306] UN Millennium Project (2005), *A Home in the City*, The report of the Millennium Project Taskforce on Improving the Lives of Slum Dwellers, Earthscan, London and Sterling VA, 175 pages.

[307] This is in line with other estimates – for instance the estimate by the Cities Alliance that $50 billion was needed to upgrade housing for 100 million slum dwellers, and the estimate of $74 billion for this by UN-Habitat; see Flood, Joe (2004), Cost Estimate for Millennium Development Goal 7, Target 11 on Slums, background report for UN Millennium Project Task Force on Improving the Lives of Slum Dwellers and UN-HABITAT, Urban Resources, Elsternwick, Australia.

Table 12: Estimated per capita costs and total investment required to upgrade slums, by region, 2005–20 ($US per capita)

Component of upgrading	Arab states, Turkey and Iran	East Asia and Oceania	Latin America & Caribbean	South Central Asia	South-east Asia	Sub-Saharan Africa, Egypt and Sudan
Construction of basic house	472	338	488	306	324	125
Purchase of land of transfer	80	38	7	32	34	14
Relocation	55	20	27	11	15	14
Provision of networked infrastructure	235	51	235	51	51	145
Provision of bulk infrastructure	71	15	71	15	15	44
Construction of schools and clinics	12	10	18	10	10	12
Construction of community facilities	15	10	15	10	10	10
Planning and oversight	268	81	230	121	126	117
Capacity building	121	56	109	56	58	48
Total cost per person	1,328	619	1,200	612	643	528
Number of people (million)	*4*	*20*	*8*	*30*	*7*	*31*
Total cost (US$)	*5.3*	*12.4*	*9.6*	*18.3*	*4.5*	*16.4*

SOURCE: UN Millennium Project (2005), *A Home in the City: The Report of the Millennium Project Taskforce on Improving the Lives of Slum Dwellers*, Earthscan, London and Sterling Va, 175 pages.

For building good-quality alternatives to "slums" through assisted self-help housing, regional estimates were also prepared, taking into account regional differences in household size, dwelling size and costs of labour, construction and building materials. Average per capita investment costs varied across regions from $285 for South Central Asia to $829 in North Africa and Western Asia (Table 13). The total resources required to fund alternatives to slums for 570 million people through assisted self-help processes is about $227 billion, of which 60 per cent ($136 billion for the whole period) would come from subsidies; the rest could be funded through savings and self-help contributions from participant families and through cost-recovery from small loans.

Table 13: Average estimated investment per person required for building alternatives to slums, by region ($US million)

Item	East Asia	Latin America & Caribbean	North Africa	Oceania	South-Central Asia	South-east Asia	Sub-Saharan Africa	Western Asia
Land	50	97	105	50	43	45	18	105
Networked infrastructure	58	306	265	58	58	58	164	265
Bulk infrastructure	17	92	80	17	17	17	49	80
Housing	169	195	292	169	131	200	77	292
Schools & clinics	10	18	12	10	10	10	12	12
Community development	30	71	75	30	26	33	32	75
Average investment per person (US$)	*334*	*780*	*829*	*334*	*285*	*363*	*352*	*829*

SOURCE: UN Millennium Project (2005), *A Home in the City: The Report of the Millennium Project Taskforce on Improving the Lives of Slum Dwellers*, Earthscan, London and Sterling Va, 175 pages.

The net conclusion from the above is that several hundred billion dollars would be required to fill the current deficits in and around urban areas in infrastructure and services, and to upgrade the worst-quality buildings. This is a cost that almost all estimates for adaptation costs have not considered. As noted above, to adapt infrastructure to climate change, you have to have the infrastructure to adapt.

Funding for adaptation

From where could the funding come for adaptation – including that needed to address the deficits discussed above? Also, within this, what should be the relative roles of international agencies, national governments, local governments, the private sector and households and community organizations? In discussions of this to date, perhaps the roles of international agencies have been given too much attention, in part because there is so little data on government investments (especially those of local governments) and on household investments. In most middle-income nations and many low-income nations (including China), aid represents a very small proportion of total government expenditures,[308] and urban areas get very little attention from most aid agencies. There is a hope that private investment can have an important role – but this too may be given too much attention. Existing data on private-sector flows to housing and infrastructure in low- and middle-income nations since 1990 show that most is concentrated in forms of infrastructure for which private enterprises can most easily charge all users – for instance in telecommunications and electricity. These are also forms of infrastructure where the costs of reaching customers and of controlling their access are lower.

The types of infrastructure that often most need investment for adaptation capacity – drainage systems, ports, roads, railways – get a low priority, as does water and sanitation.[309] Large private investment flows had been expected into water and sanitation, especially with the support given by many international agencies to privatization and private-sector involvement – but generally the international companies that became important in this did not bring major new capital sources.[310] Most private investments in urban infrastructure are concentrated in wealthier nations in wealthier regions; sub-Saharan Africa and the least developed nations, which most need such investments, get a very low proportion.[311] Both now and in the future, it is difficult to see how private investments can have a major role in the poorest nations and in nations with poor economic performance (which include many that are most at risk from climate change) and in those kinds of infrastructure which are public goods and are particularly important for protecting the poorest and most vulnerable groups (for instance most roads/bridges and storm and surface-water drainage).

NAPA estimates

For the first nine countries to submit their National Adaptation Programmes of Action (NAPAs), estimated project costs totalled US$178 million. Based on this, the cost of meeting just the most urgent and immediate priorities of the 49 Least Developed Countries will be around US$1 billion. The NAPA process to date shows that the cost of adaptation could be very high, to the extent that it could not be met by a single source of funding. Few NAPA projects have an urban focus, but the costs of some that do are as follows.

- Enhancing resilience of urban infrastructure and industries to impacts of climate change including floods and cyclones, Bangladesh: US$2 million.
- Glacial lake outburst flood hazard zoning (Pilot Scheme – Chamkhar Chu Basin), Bhutan: US$0.2 million.
- Stabilization of river dynamics of river courses in Mumirwa and Imbo, Burundi: US$2.03 million.
- Improvement of water quality for rural and urban populations, Comoros: US$80,000.
- Fight against malaria in populations from the rural and urban areas with a high rate of malaria, Comoros: US$175,000.

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[308] The World Bank (2006), *2006 World Development Indicators Online,* The World Bank, Washington DC.
[309] Briceno-Garmendia, Cecilia, Antonio Estache, and Nemat Shafik (2004), *Infrastructure Services in Developing Countries: Access, Quality, Costs and Policy Reform*, Policy Research Working Paper Series 3468, World Bank, Washington DC, 33 pages.
[310] Budds and McGranahan (2003), op. cit.
[311] See for instance Briceno-Garmendia et al. (2004), op. cit.

- Use of non-metallic local materials for the construction of low-price housing, Comoros: US$1.025 million.
- The implementation of a safeguard plan for the city of Nouakchott and its infrastructures, Mauritania: US$2.091 million.
- The protection and reinforcement of the dune bar along the coastline in Nouakchott, Mauritania: US$1.018 million.
- Zoning and strategic management planning project in Apia, the capital of Samoa, Samoa: US$400,000.

Adaptation to water stress or scarcity

For urban areas, adaptation to water stress or scarcity that climate change may bring or exacerbate needs to be reviewed in light of the very large deficiencies in provision for water and wastewater management that were outlined above. Water scarcity is rarely the main reason why provision for water is so inadequate in cities. There is no association between nations facing water stress and nations with the largest inadequacies in provision for water (for rural and urban populations).[312] Many large cities where provision for water (and sanitation) is very inadequate have little or no overall shortage of freshwater resources.[313] Many case studies for particular cities with water shortages also show that these are more the result of poor management than of water scarcity.[314] There has been limited progress in most nations in improving and extending provision for water and sanitation within urban populations, and international donor support for privatization has not produced the hoped-for expansion in provision or the increase in capital investment.

Generally, the cities with the best-managed provision for water and sanitation are those with the greatest capacity for adaptation. Any planning for better meeting present or future needs for water should consider how climate change may influence supplies and demand – not least because most water infrastructure is planned for a long life (50 to 100 years), and for most cities there are long lead times (and often high costs) for schemes which significantly increase freshwater supplies.

Lessons from the past 40 years of development assistance have shown that good provision for water and sanitation is not only about infrastructure. It is also about local capacity to make appropriate choices in regard to the technology used and the institutional forms for building and managing it. This includes a local capacity to innovate, when conventional methods do not work. It is also about finding local possibilities for all those who need water to get their needs met – and the informal private sector (water vendors, kiosks and small-scale piped suppliers) often has considerable importance. In many settings, it is also about local possibilities for partnerships between government agencies, private enterprises, community organizations and, often, local NGOs – or at least an acceptance by government of the role of other service providers.[315]

As with adaptation for extreme weather, it is difficult to suggest costs for making water and wastewater systems resilient to the likely impacts of climate change when there are such large backlogs in the infrastructure to provide safe, sufficient freshwater supplies (and manage the disposal of wastewater). Discussions of adaptation in high-income nations usually factor in demand-management as an alternative to increasing supplies but in most cities in low- and middle-income nations, there is a need to increase supplies to provide a less intermittent, better-quality service and to extend piped supplies to those unserved.

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[312] McGranahan, Gordon (2002), *Demand-Side Water Strategies and the Urban Poor,* PIE Series No. 4, IIED, London, 67 pages; UN-Habitat (2003), *Water and Sanitation in the World's Cities*, op. cit.

[313] UN-Habitat (2003), *Water and Sanitation in the World's Cities,* op. cit; also Connolly, Priscilla (1999), "Mexico City: our common future?", *Environment and Urbanization*, Vol. 11, No. 1, April, pages 53–78; and Anton, Danilo J. (1993), *Thirsty Cities: Urban Environments and Water Supply in Latin America*, IDRC, Ottawa, 197 pages.

[314] Hardoy, Mitlin and Satterthwaite (2001), op. cit., UN-Habitat (2003), *Water and Sanitation in the World's Cities,* op. cit.; UN-Habitat (2006), op. cit.

[315] UN-Habitat (2006), op. cit.

A recent paper on how water management could lead adaptation to climate change illustrates the difficulties facing water managers: the uncertainties within each locality of likely changes in temperature, rainfall, evaporation, infiltration and runoff make it very difficult to factor climate change into current decisions. Yet decisions made now will influence future water availability and the extent of adaptation possibilities. Mike Muller illustrates this by noting the two main options for increasing water supply to Johannesburg (South Africa's industrial heartland and largest city); both options cost over a billion dollars and will take up to ten years to plan and build.[316] It is likely that climate change will influence the unit costs of water and other aspects for both schemes, but it is not certain how.

Adaptation that meets the needs of the urban poor

The very substantial costs of addressing the deficiencies in infrastructure and services for "slums" and informal settlements and supporting better-quality housing for low-income urban dwellers was noted above. The total costs represent hundreds of billions of dollars and are far more than international agencies can provide – or would be prepared to provide (as most give little or no priority to this area).

The Stern Report is unusual among discussions of climate change in its explicit recognition that climate-change adaptation in low- and middle-income nations has to reduce the vulnerability of low-income groups. If "development" had been more successful in reducing poverty over the last five decades, adaptation costs would be much lower. Stern notes the key areas of development action that will help reduce vulnerability to the effects of climate change:

- progress on achieving income and food security and on overcoming the structural causes of famine/insecurity;
- building robust education and health systems, including eradication of malaria, cholera, and other diseases associated with water;
- better urban planning and provision of public services and infrastructure; and
- better gender equality.[317]

To this might be added the need to change relationships between local governments and poorer groups, since much of the vulnerability of poorer groups to environmental hazards, including those related to climate change, is rooted in the incapacity of local governments and often in their "anti-poor" attitudes and policies.

If city and national governments and international agencies do begin to factor climate-change-related risk reduction into their urban policies, how can this avoid further disadvantaging the urban poor? How can the interests of those who live in the informal settlements and work in the informal economy come to represent a sufficiently potent political force to get risk-reduction investments that benefit them? How can the inhabitants of informal settlements most at risk from flooding get to influence "solutions"?

The adaptation literature talks in rather general terms about potential roles of micro-finance and of safety nets. Of course, both have important potential roles in reducing vulnerability. But what is needed is a discussion of how these can be made available and by whom to whom. Again the obvious point – local governments who regard much of their low-income population as "squatters" and "trespassers" will not provide these groups with safety nets. The limitations of micro-finance should also be recognized; however efficiently it is provided, individuals and households with low-incomes need to avoid debt burdens wherever possible – and the costs of many key adaptations, especially in relation to housing (safer sites, better buildings, better infrastructure and services) will generally be much higher than what low-income households can afford, even with efficient micro-finance.

However, there are examples of the kinds of pro-poor actions that are possible.

- The precedents for the relocation of those living in informal settlements in risky sites in which the inhabitants of these settlements and their own representative organizations were fully involved in where, when and how they were moved.[318]

[316] Muller (2007), op. cit.
[317] Stern (2007), op. cit.
[318] Patel, d'Cruz and Burra (2002), op. cit.

- The political innovations that have given low-income groups more influence over public investment decisions and brought greater accountability to them in how government resources are used.[319]
- The many examples of federations formed by groups of slum and shack dwellers or homeless people that are pushing pro-poor political changes and also implementing many upgrading and new-house developments. Some city and national governments have recognized that these can be powerful and very effective partners in improving living conditions.[320] Their innovations in providing the information base needed for upgrading – the household enumerations and maps developed for informal settlements at a city-wide scale – was noted above.
- The many civil-society organizations that can help to ensure that city planning and investment are less anti-poor and anti-environment. For instance, the Urban Resource Centre in Karachi has demonstrated its capacity to influence urban planning in Karachi; this is a small NGO founded by teachers, professionals, students, activists and community organizations from low-income settlements. This Resource Centre's influence is from creating an information base about Karachi's development on which everyone can draw, combined with research and analysis of government plans (and their implications for Karachi's citizens), advocacy, mobilization of communities, and drawing key government staff and the media into discussions. The network that this Resource Centre has built has successfully challenged many government plans that are ineffective, over-expensive and anti-poor, and it has devised and promoted alternatives. It shows how the questioning of government plans in an informed manner by a large number of interest groups, community organizations, NGOs, academics, political parties and the media can force the government to listen and make modifications to its plans, projects and investments. Comparable urban resource centres have been set up in other cities in Pakistan and also in other nations.[321]

One final issue in relation to adaptation that meets the needs of the urban poor is in relation to health services and emergency services. As with infrastructure, it is difficult to estimate adaptation costs when existing provision (which has to be adapted to new risks) is so inadequate. One study suggests that changes in heath care expenditure in response to climate change do not represent a high proportion of total GDP – but the same source also notes how the adaptation costs will be higher in low-income nations where there is less capacity to afford them, and that even low-cost adaptation strategies "can be very costly in a low-income country."[322]

Existing and potential links between adaptation and mitigation

How can mitigation and adaptation strategies be bridged to address climate-change vulnerabilities in cities? How does bridging the issues strengthen or weaken either or both agendas? Table 14 contrasts different aspects of mitigation and adaptation. It highlights the point stressed already – that successful adaptation depends on good local knowledge and local capacity. Obviously, any attention to adaptation must not draw attention from mitigation – and mitigation is central to reducing the need for adaptation. It must also be repeated that almost all adaptation implies costs and these are likely to rise rapidly without effective mitigation – as will the numbers of homes, livelihoods, settlements, cities and ultimately lives that adaptation is unable to protect.

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[319] Menegat 2002, op. cit.; Souza, Celina (2001), "Participatory budgeting in Brazilian cities: limits and possibilities in building democratic institutions", *Environment and Urbanization*, Vol. 13, No. 1, pages 159–184; and Cabannes (2004), op. cit.

[320] See case studies of federations in the Philippines, India and Zimbabwe in *Environment and Urbanization*, Vol. 13, No. 2, 2001; also Weru, Jane (2004), "Community federations and city upgrading: the work of Pamoja Trust and Muungano in Kenya", *Environment and Urbanization*, Vol. 16, No. 1, pages 47–62; D'Cruz and Satterthwaite (2005), op. cit.; also www.sdinet.org for up-to-date profiles of the different federations.

[321] Hasan (2007), op. cit.

[322] Bosello et al. (2007), op. cit., page 56.

Table 14: Characteristics of mitigation and adaptation

	Mitigation	**Adaptation**
Benefited systems	All systems	Selected systems
Scale of efforts	Global	Local to regional
Life time	Centuries	Years to centuries
Lead time	Decades	Immediate to decades
Effectiveness	Certain, in terms of emission reduction; less certain in terms of damage reduction	Generally less certain (*especially where local knowledge of likely climate-related changes is weak)*
Ancillary benefits	Sometimes	Mostly
Polluter pays	Typically yes	Not necessarily
Payer benefits	Only a little	Almost fully
Administrative scale/implementing bodies	(Mainly) national governments/international negotiations	(Mainly) local managers/authorities, households (*& community organizations)*
Sectors involved	Primarily energy and transport in high-income nations, forestry and energy in low/middle-income nations	Potentially all
Monitoring	Relatively easy	More difficult

SOURCE: Bosello, Francesco, Onno Kuik, Richard Tol and Paul Watiss (2007), *Costs of Adaptation to Climate Change: A Review of Assessment Studies with a Focus on Methodologies Used*, Ecologic, Berlin, 112 pages. Text in italics added by authors of this paper.

VI. NEXT STEPS

It is not surprising that most city governments and most ministries and agencies at higher levels of government in low- and middle-income countries have not given much attention to climate-change adaptation within their urban policies and investments. Where governments are representative and accountable to poorer groups, they generally have more pressing issues, including large backlogs in provision for infrastructure and services and much of their population living in poor-quality housing. They are also under pressure to improve education, health care and security – and are looking for ways of expanding employment and attracting new investment.

Unless adaptation to climate change is seen to support and enhance the achievement of development goals, it will remain marginal within government plans and investments. Perhaps as importantly, the need for adaptation highlights the importance of strong, locally driven development that delivers for poorer groups and is accountable to them. Similarly, the extreme vulnerability of large sections of the urban population to many aspects of climate change reveals the deficiencies in "development". Unless these deficiencies are addressed, there is no real basis for adaptation. It is very difficult to conceive of how to get pro-poor and effective adaptation in nations with weak, ineffective and unaccountable local governments. This is especially so in the many nations that also have civil conflicts and no economic or political stability. Many of the nations or cities most at risk from climate change lack the political and institutional base to address this. Even if we can conceive of how this might be addressed, it is difficult to see how existing international institutions as they are currently configured can do so.

Mechanisms for financing adaptation

Several financial mechanisms exist under the United Nations Framework Convention on Climate Change (UNFCCC) to support adaptation, particularly in low- and middle-income countries. The Global Environment Facility (GEF) manages most of the funds, including four mechanisms with a total of US$310.22 million (received and pledged), as follows.

1. The Least Developed Countries Fund contains voluntary contributions from several high-income countries. It has already supported the development of National Adaptation Programmes of Action (NAPAs) by the Least Developed Countries (LDCs) and will likely assist the LDCs in implementing their NAPA projects. The Fund has received $48.27 million, and has another $104.81 million pledged.

2. The Special Climate Change Fund is for all low- and middle-income countries and covers adaptation and other activities such as technology transfer, mitigation and economic diversification. It is also based on voluntary contributions from high-income countries and has started to support some adaptation projects in a few countries. It has received $40.62 million, and has another $61.52 million pledged.
3. The Adaptation Fund is meant to support "concrete adaptation" activities. It was established under the Kyoto Protocol, whereas the first two funds were established under the UNFCCC. Operating rules are under negotiation. The Fund is based on private-sector replenishment though the 2 per cent levy on Clean Development Mechanism projects (which channel carbon-cutting energy investments – financed by rich-country companies – to low- and middle-income countries), plus voluntary contributions from high-income nations. The Fund contains $5 million, pledged by Canada.
4. The Strategic Priority on Adaptation contains US$50 million from the GEF's own trust funds to support pilot adaptation activities over three years. The fund is already supporting several adaptation projects, but may not continue after the pilot phase.

A number of bilateral aid agencies, including those from Canada, Germany, the Netherlands, Japan, the United Kingdom and the United States have allocated funding for adaptation activities, including research and some pilot projects. To date, bilateral donors have provided around $110 million for over 50 adaptation projects in 29 countries.[323] More bilateral development funding agencies are beginning to allocate amounts for adaptation although these are likely to be only tens of millions of dollars. In addition, World Bank funding for adaptation activities totalled around $50 million between 2001 and 2006, channelled mainly through the GEF.[324]

At present, the international funding pledged for supporting adaptation in low- and middle-income nations is dwarfed by the investments being made or planned for adaptation in high-income nations. The UK, which has so far pledged $38 million to international adaptation funds, is investing £178 million ($347 million) in new climate-cooling systems for the London Underground.[325] Total spending on flood management in the UK was budgeted at £600 million (c. $1,200 million) for 2005–6 alone.[326] Adaptation costs in the UK, reforming standards and regulations for new buildings and infrastructure and retrofitting and refurbishing existing stock, could lead to a 1–5 per cent increase in current construction costs to meet these challenges.[327] This is projected to lead to costs of £3.6–£26 billion (base year 2000) (around US$7.2–52 billion) aggregated over the building stock. The Netherlands has so far pledged $18 million to international adaptation funds but is spending €2.2 billion ($2.9 billion) at home to re-zone flood areas and reposition dykes by 2015.[328] After France's heatwave of 2003, the Health Minister committed $748 million in extra funding for hospital emergency services.[329] In Germany, a new sea-wall is being constructed for the city of Hamburg, costing €600 million ($800 million), and which doesn't even take full account of climate-change threats.

Existing official statistics show that most bilateral aid agencies give a low priority to "economic infrastructure" – for instance for transport and communications and energy – and to water supply and sanitation. Economic infrastructure generally gets less than 10 per cent of bilateral agency commitments,

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[323] Frankel-Reed, Jennifer (2006), *Emerging Approaches in Climate Change Adaptation from Theory and Practice*, Unpublished Master's thesis, cited in Burton, I., E. Diringer and J. Smith (2006), *Adaptation to Climate Change: International Policy Options,* The Pew Center on Global Climate Change, Virginia, 28 pages.
[324] World Bank (2006), op. cit.
[325] Darsh, G. (2006), *The Impact of Climate Change on London's Transport Systems*, CIWEM Met Branch Conference 22 February 2006, ATKINS (available at www.ciwem.org/branches/metropolitan/ClimateChange_Met_3.pdf).
[326] See www.defra.gov.uk/environ/fcd/policy/funding.htm
[327] McKenzie Hedger, M., I. Brown, R. Connell and M. Gawith (2000), *Climate Change: Assessing the Impacts – Indentifying Responses*, Department of the Environment, Transport and Regions, UK Climate Impacts Programme, London.
[328] McKenzie Hedger, M. and J. Corfee-Morlot (2006), *Adaptation to Climate Change: What Needs to Happen Next?* Report of a Workshop in the UK, EU Presidency, Environment Agency and Department for Environment, Food and Rural Affairs, London.
[329] WHO (2003), "France Caught Cold by Heatwave", *Bulletin of the World Health Organization*, Vol. 81, No. 10, pages 773–774.

while water supply and sanitation generally gets less than 5 per cent.[330] Japan is the main exception, but its aid programme has long been more explicitly structured to supporting improved infrastructure for its current or likely future main trading partners.[331] The European Community's aid programme and the development finance provided by the World Bank and the regional development banks generally give economic infrastructure a higher priority – although this still constituted less than a fifth of the EC funding commitments and just over a fifth of the World Bank funding commitments in 2005.

In general, most bilateral and multilateral aid agencies have moved away from a focus on economic infrastructure – in part because of the difficulties they had in ensuring that the infrastructure they funded was maintained. Many bilateral agencies now channel a considerable proportion of their funding to "budgetary support" in the hope that this will increase recipient government buy-in and improve coordination between all the different international agencies. In such circumstances, obviously, if national governments prioritize the kinds of investments that help adaptation, this will increase donor funding to it. Donor support for "good governance", if effective, might increase the competence and capacity of local governments to do so – but most support for "good governance" is for national government, not for local governments.

In most middle-income nations and in India and China, the proportion of total funding into infrastructure that comes from aid agencies and multilateral development banks is likely to be relatively small. In many low-income nations, it is more significant, but often only because of so little investment by national and local governments. The key point to note here is that **the scale of donor funding for infrastructure is very small in relation to the deficits in infrastructure provision.**

If Oxfam's estimates of at least US$50–80 billion each year for low- and middle-income countries to adapt to climate change[332] are to be believed, the scale of existing funding clearly comes nowhere close to matching adaptation needs. Total donor commitments for all purposes in 2005 were around $120 billion. NAPAs alone suggest that funding for managing climatic risks will need to go beyond existing adaptation funds, the international climate-change regime and bilateral action. Several further potential sources exist.

- *An international air travel adaptation levy*: in 2006 there were 2 billion air travellers, with 800 million of them on international flights. A levy of $10 on each ticket could raise $8 billion for adaptation each year.
- *A levy on carbon trading*: the principle of the 2 per cent levy from the Clean Development Mechanism that goes into the Adaptation Fund could be extended to other carbon-trading mechanisms. Likewise, a levy could be introduced into emerging national and regional carbon markets, such as the European Emission Trading Scheme.
- *Carbon taxes in high-income countries*: a percentage of revenue raised from national carbon taxes could be directed to adaptation funds. For example, Sweden introduced a carbon tax in 1991 and Japan has mandated a "household energy tax" equivalent to $21 per ton of carbon. In 2005 a carbon tax was introduced in New Zealand, raising an extra $2 a week for electricity, petrol and gas from the average household.
- *Ending fossil-fuel subsidies*: since the late 1990s, the OECD countries have collectively subsidized domestic fossil fuel production and consumption in the range of $10–57 billion each year. For example, the UK government gives an effective annual subsidy of £9 billion ($17.5 billion) to the airline industry in waived taxes on fuel.
- *Corporate contributions*: companies operating in the fossil-fuel industry, for example, have profited significantly from the sale of fossil fuels in recent years, and have the capability to assist, given their strong profits over the past decade.
- *Individual donations*: as seen in 2005, when people around the world donated almost $5.5 billion to help deal with the Asian Tsunami crisis.

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[330] Statistics in this and the subsequent paragraph on development assistance flows and priorities come from the statistical annex of the 2006 OECD Development Cooperation Report (accessed at http://www.oecd.org/statisticsdata/0,2643,en_2649_33721_1_119656_1_1_1,00.html).

[331] For more details of this, see Satterthwaite (2001), op. cit.

[332] Oxfam (2007), *Adapting to Climate Change: What's Needed in Poor Countries, and Who Should Pay*, Oxfam Briefing Paper 104, Oxfam, Banbury, 47 pages.

A second challenge for those financing adaptation is the need to separate the additional costs of climate-change adaptation from "business as usual" development activities. But this is very difficult. In addition, as emphasized above, successful development contributes much to adaptive capacity. Those who want to fund climate-change adaptation may want to clarify the difference between risks and vulnerabilities related to climate change, and risks and vulnerabilities related to climate variability independent of climate change. From a development perspective, the two need to be integrated. But while the separation may pose many practical challenges, it may be necessary to distinguish between the responsibility (and hence liability) of high-income countries to pay for the damage they have caused (according to the "polluter pays" principle), and funds donated under the banner of philanthropy or charity. For this reason, funding for climate change needs to be in addition to existing aid flows – even if the funding it provides needs to be strongly integrated within development investments. In practice, requirements for detailed additional costs (which are usually virtually impossible to ascertain) are being increasingly waived in favour of approximations.

Another key issue to be resolved is who and what should be prioritized for receiving international funds for supporting adaptation? Should some countries receive priority over others? Or should some sectors and communities be prioritized, and if so on what basis? These issues are still under discussion in the UNFCCC and the bilateral funding agencies themselves, and have yet to be resolved.

Donor "climate-screening" of investment portfolios

Climate change has traditionally received little attention from international donor organizations. A review of 136 projects in Africa funded by the German donor GTZ found no references to climate change.[333] International organizations such as the International Monetary Fund and World Trade Organization give little consideration to climate issues in their work. A study by the Organization for Economic Cooperation and Development revealed the magnitude of development assistance and aid in sectors potentially affected by climate risks.[334] In Egypt and Bangladesh alone, from 1998 to 2002, between US$1 billion and US$2 billion was directed to sectors affected by climate change and climate variability. As much as 50–65 per cent of development aid in Nepal was given to climate-sensitive sectors.

Clearly, international donor agencies need to assess the extent to which their investment portfolios in low- and middle-income countries might be at risk due to climate change, and take steps to reduce that risk. This is increasingly recognized, and several bilateral and multilateral development agencies and NGOs are starting to take an interest.[335] At least six development agencies have screened their project portfolios both to ascertain the extent to which existing development projects consider climate risks or address vulnerability to climate variability and change, and to identify opportunities for incorporating climate change explicitly into future projects. Donor agencies and NGOs that have started to examine their investment and project portfolios in this way include the World Bank in India, the UK Department for International Development (DFID) in India, China and Kenya, the Netherlands Department for Development Assistance (DGIS) in Bolivia, Bangladesh and Ethiopia, the International Institute for Sustainable Development (IISD) and the International Union for the Conservation of Nature and Natural Resources (IUCN). Most agencies already consider climate change as a real but uncertain threat to future development, but they have given less thought to how different development patterns might affect it.

Conclusion: some final reflections on the distribution of costs

When considering adaptation, it is easy to get lost in the details of what needs to be done – or in producing "cost–benefit" ratios for nations or regions that do not consider who bears the costs and where

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[333] Klein, R.J.T. (2001), *Adaptation to Climate Change in German Official Development: An Inventory of Activities and Opportunities, with a Special Focus on Africa*, Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany.

[334] OECD (2003), Special Issue on Climate Change: Climate Change Policies: Recent Developments and Long-Term Issues, *OECD Papers*, Vol. 4, No. 2, Organization for Economic Cooperation and Development (OECD) publications, Paris.

[335] Agrawala, S. (2004), "Adaptation, development assistance and planning: challenges and opportunities", *IDS Bulletin Climate Change and Development*, Vol. 35, No. 3, pages 50–53; Klein (2001), op. cit.

they are concentrated. Some examples were noted above of benefit–cost ratios suggesting that certain key cities were unviable – including cities that are central to the current and future development prospects of whole nations.

Discussions of adaptation must also remember the profound unfairness globally between those who cause climate change and those who are most at risk from its effects.[336] This can be seen in three aspects. First, in regard to people, it is the high-consumption lifestyles of the wealthy (and the production systems that meet their consumption demands) that drive climate change;[337] it is mostly low-income groups in low- and middle-income nations with negligible contributions to climate change who are most at risk from its impacts. Second, in regard to nations, it is within the wealthiest nations that most greenhouse gases have been emitted, but mostly low- and middle-income nations that are bearing and will bear most of the costs. Third, in regard to cities, larger companies and corporations can easily adjust to new patterns of risk induced by climate change and move their offices and production facilities away from cities at risk. But cities cannot move. And all cities have within them the homes, cultural and financial assets, and livelihoods of their inhabitants, much of which cannot be moved.

There are figures to show the dramatic differences between nations in average contributions per person to greenhouse-gas emissions – for instance the 80-fold difference between that of the USA and many low-income nations. But these actually understate the scale of these differentials. Greenhouse-gas emissions in high-income nations are kept down by the fact that they import many of the energy-intensive goods used or consumed by their citizens and businesses. In addition, a concentration on comparing "averages" for nations obscures just how much the problem is driven by wealthy groups. The differentials in greenhouse-gas emissions per person between rich and poor groups can be much larger than the differentials between rich and poor nations. For instance, the greenhouse-gas emissions generated as a result of the high-consumption lifestyle of a very wealthy person or household is likely to be hundreds of thousands or even millions of times more than that generated by many low-income households in low-income nations.[338]

The very survival of some small-island and some low-income nations (or their main cities) is in doubt as much of their land area is at risk from sea-level rise, yet their contributions to global greenhouse emissions have been very small. There are also tens of millions of people in low- and middle-income nations whose homes and livelihoods are at risk from sea-level rise and storms, although they have made very little contribution to global warming. The economic cost of losing certain cities for which adaptation costs are too high may be relatively small for national economies. But what will happen to international relations as increasing numbers of people lose their homes, assets, livelihoods and cultural heritages to climate-change-related impacts – especially when the main causes of this are strongly associated with the lifestyles of high-income groups in high-income nations, and the reason for their loss is the failure of high-income nations to cut back their emissions? Would the US government oppose the Kyoto Protocol's modest targets for emission reductions if Washington DC, New York and Los Angeles faced risks comparable to those facing Dhaka, Mumbai, Lagos and Bangkok – as a result of greenhouse-gas emissions the US had not generated?

Adaptation plans must not in any way slow progress towards mitigation. It is obvious that adaptation will be easier and cheaper if greenhouse-gas emissions are reduced – so both the amount of adaptation and the rate at which it must be implemented are lessened. Adaptation plans must also bring benefits to the billion urban dwellers currently living in very poor-quality housing, in tenements, cheap boarding houses and illegal or informal settlements. These billion people include a large part of the population whose homes and livelihoods are most at risk from climate change. A technology-driven, market-led response

[336] This final section draws on Huq, Saleemul, Sari Kovats, Hannah Reid and David Satterthwaite (2007), "Editorial: Reducing risks to cities from disasters and climate change", *Environment and Urbanization*, Vol. 19, No. 1, pages 3–15.

[337] This might be considered to understate the role of industry or particular sectors such as fossil-fuel-powered electricity generation but their production (and the climate-change implications of their production) are underpinned by consumer demand, much of it from those with high-consumption lifestyles. It might also be considered to understate the contributions of middle-income groups in high-income nations – but these are among the wealthy, if the whole planet's population is considered.

[338] Hardoy, Mitlin and Satterthwaite (2001), op. cit.

to climate change does little for them.

The key issue is how to build resilience to the many impacts of climate change in tens of thousands of urban centres in low- and middle-income nations. Such measures should:

- support and work with the reduction of risks from other environmental hazards, including disasters (noting the strong complementarities between reducing risk from climate change, non-climate-change-related disasters and most other environmental hazards);
- be strongly pro-poor (most of those most at risk from climate change and from other environmental hazards have low incomes, which limits their autonomous adaptive capacity);
- build on the knowledge acquired of reducing risk from disasters in urban areas;
- be based on and build a strong *local* knowledge base of climate variabilities and of the likely local impacts from climate-change scenarios;
- encourage and support actions that reduce risks (and vulnerabilities) now, while recognizing the importance of measures taken now to begin the long-term changes needed in urban form and the spatial distribution of urban populations to reduce vulnerability to risks that may become manifest only several decades in the future;
- recognize that the core of the above is building the competence, capacity and accountability of city and sub-city levels of government and changing their relationship with those living in informal settlements and working in the informal economy – and the importance within this of supporting civil-society groups, especially representative organizations of the urban poor (this is also to avoid the danger of 'adaptation' providing opportunities for powerful groups to evict low-income residents from land they want to develop);
- recognizes that government policies must encourage and support the contributions to adaptation of individuals, households, community organizations and enterprises;
- recognize the key complementary roles required by higher levels of government and international agencies to support this (and that this requires major changes in policy for most international agencies that have long ignored urban issues and major changes in how adaptation is funded);
- also build resilience and adaptive capacity in rural areas – given the dependence of urban centres on rural production and ecological services and the importance for many urban economies and enterprises of rural demand for (producer and consumer) goods and services;
- and build into the above a mitigation framework too (if successful cities in low- and middle-income nations develop without this, global greenhouse gas emissions cannot be reduced).

ANNEXE: Urgent and immediate adaptation needs from NAPAs: urban projects

NAPAs (National Adaptation Programmes of Action) provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs for adaptation to climate change. These urgent and immediate needs are those for which further delay could increase vulnerability or lead to increased costs at a later stage. The steps for the preparation of the NAPAs include identification of key adaptation measures and selection of a prioritized shortlist of activities. NAPAs also include short profiles of projects and/or activities intended to address urgent and immediate LDC adaptation needs.

The rationale for NAPAs rests on fact that LDCs are among the countries most vulnerable to the adverse effects of climate change, in part because of their low capacity to adapt. As of April 2007, 14 of the 49 LDCs had submitted their NAPA to the UN Framework Convention on Climate Change (UNFCCC): Bangladesh, Bhutan, Burundi, Cambodia, Comoros, Djibouti, Haiti, Kiribati, Madagascar, Malawi, Mauritania, Niger, Samoa and Senegal. Of these, priority sectors covered by the assessments, and consequently those that are going to be the focus of the proposed NAPA projects, are health, agriculture, water resources and forests. Although the NAPA assessments involved different population groups, more emphasis was placed on the rural poor. Stakeholder groups such as farmers, herders and fishers were targeted, with less attention given to the urban poor.[339] The following urban projects have been extracted from the NAPAs available in English from the UNFCCC website (Bangladesh, Bhutan, Burundi, Cambodia, Comoros, Kiribati, Malawi, Mauritania, Niger and Samoa).

Bangladesh: Enhancing resilience of urban infrastructure and industries to impacts of climate change including floods and cyclones

Urban infrastructure in the major cities of Bangladesh will be adversely affected by climate-change impacts, especially floods and cyclones. The infrastructure therefore needs to be made more resilient, to withstand those impacts. This project aims to enhance resilience to climate change (including floods and cyclones) in urban and industrial sectors in major cities through capacity building and policy and awareness-raising activities. Activities include developing better:

- building codes for the building industry and infrastructure in potentially vulnerable areas;
- industrial waste management, and community-based safe dumping places for pollutants;
- early-warning systems.

Bhutan: Glacial lake outburst flood (GLOF) hazard zoning (Pilot scheme – Chamkhar Chu Basin)

The Chamkhar Chu River is fed by the glaciers of Gangkar Punsum and the Monla Karchung ranges. A total of 557 glacial lakes with a total area of 21.03 square kilometres drain into the Chamkhar Chu River which flows though the valley of Jakar, a key tourist destination with many local businesses, hotels, shops and cottage industries. The Bumthang District is also one of the most important Buddhist pilgrimage destinations in the Himalayas with many historical monuments, temples, monasteries, and religious sites. Plans to move the town of Chamkhar to Dekiling do not adequately consider GLOF threats. Neither do other activities in the valley. Hazard zoning at this critical stage in the valley's development would better prepare people in the event of a GLOF event. The main objective of this project is, therefore, to prepare a hazard-zoning map for GLOF (from Khaktang to Chamkhar town), covering the locations of main settlements and development activities.

Burundi: Stabilization of river dynamics of river courses in Mumirwa and Imbo

The Imbo lowlands and Mumirwa are very sensitive to lateral and vertical erosion, particularly during periods of heavy rainfall. This erosion can lead to landslips and alluvial deposits, which are likely to increase with climate change. Urban areas, in particular the city of Bujumbura, are particularly vulnerable to erosion, which must be reduced or prevented to preserve both public and private

[339] Osman-Elasha and Downing (2007), op. cit.

infrastructure in the area. The channelling of rainwater into rivers and torrents is necessary to protect the urban bridges, roads, buildings and other infrastructure, and to ensure viable sanitation. Activities include:

- enhancing meteorological and hydrological observation networks;
- conducting a study of river dynamics in connection with precipitation conditions;
- establishing a town-planning and development master plan of the lowlands, taking into account the risks related to precipitation fluctuations;
- establishing plans for the correction and stabilization of rivers and the protection of infrastructure;
- conducting work to correct and stabilize these rivers, starting with those that cross the town of Bujumbura;
- developing legislation on public safety for disaster situations;
- mapping the zones at risk, and proposing land-use standards in these zones.

Comoros: Improvement of water quality for rural and urban populations

River water provides most of the water resources on the islands of Anjouan and Mohéli. The quality of this water has fallen due to its scarcity, overexploitation due to increasing need, and the effects of erosion. Contaminated water causes frequent cases of hepatitis and typhoid fever, which have killed many islanders. In Grand-Comoro, tank water is also poor, and rising sea levels have increased the salinity of underground water resources. This project aims to provide communities with access to drinking water to preserve their health in the context of climate-change-induced precipitation fluctuations and degradation of water quality. Activities will include:

- setting up water-treatment infrastructure;
- providing training on water treatment;
- setting up protection perimeters around water sources;
- improving public awareness on water hygiene.

Comoros: The fight against malaria in rural and urban areas with high rates of malaria

Malaria is a major public health problem in the Union of the Comoros. Because of temperature rises, it now occurs at altitudes that used to be spared. It is the main reason for medical consultation and hospitalization, and is responsible for 25 per cent of deaths recorded for children under five years. Children and pregnant women are particularly vulnerable. This project aims to enable rural and urban communities to fight the climate-variability-induced geographic spread and intensification of malaria. Activities will consist of:

- eliminating the larva shelters inside and around houses;
- reducing the proliferation of mosquitoes in the water mains by introducing larva-eating fish;
- educating and mobilizing communities to promote behaviour that is conducive to the prevention of and fight against malaria;
- encouraging the distribution and use of long-lasting, impregnated mosquito nets.

Comoros: Use of non-metallic local materials for the construction of low cost housing

About 25 to 60 per cent of Comorian families in Grand Comoro, Anjouan and Mohéli live in cob or straw houses with a wooden frame. Such houses are vulnerable to bad weather. The increase in cyclone frequency and other extreme climatic events during the last few years has already led to significant material losses and damaged the lives of many families. Access to concrete housing is limited to privileged families due to the high costs of this method of construction. Such houses can resist rain and last for several decades, whereas straw constructions must be renewed every year. Using new, locally produced materials will decrease construction costs and provide poor populations in high-risk areas with more resilient housing. Comfort and security will increase for these people, as will sanitation facilities (which will also be produced locally).

Mauritania: The implementation of a safeguard plan for the city of Nouakchott and its infrastructure

In recent decades, the Nouakchott coastline has experienced accelerated urbanization due to the deteriorating climate, which has caused crises in rural areas. Nouakchott currently accommodates over 25 per cent of Mauritania's population, and a large part of its industry (which includes fish processing, tourism and construction), commerce and other socio-economic infrastructure. Most of Nouakchott's suburbs and much of its economic infrastructure (some of which is vital to national development) is in low areas susceptible to flooding. Climate change could therefore affect communities, homes, infrastructure and the whole economy of the region and country. This project therefore aims to:

- introduce and enforce town-planning standards that take climate change into consideration, for example by revising plans to accommodate sea-level rise;
- draw up a development plan for the Nouakchott coastline;
- provide security for over 80 per cent of Nouakchott inhabitants located in higher-risk areas by building a breakwater 1.5–2 metres high and 5–6 metres wide along the whole of the west front of Nouakchott;
- relocate over 60 per cent of the infrastructure established on the dunes, and orchestrate a planned removal of all infrastructure in sectors susceptible to climate-change effects;
- create awareness among contractors and subcontractors about appropriate construction methods in risky areas.

Mauritania: The protection and reinforcement of the dune bar along the coastline in Nouakchott

The sand of the coastal bar provides Nouakchott with its only natural protection from heavy storms. Yet this sand is currently overexploited and the dune bar has been weakened in various places. The bar has also been weakened by uncontrolled development. With climate change likely to increase the frequency and intensity of storms, this is likely to result in heavy flooding in most town districts. This project therefore aims to:

- introduce and make operational a supervisory structure to protect the coastline bar;
- reconstruct and cover in vegetation over 80 per cent of the weakened coastline dunes;
- create awareness in the Nouakchott population of the dangers of the dune bar giving way, and what measures people should take to protect themselves.

Samoa: Zoning and strategic management planning project

Apia, the capital of Samoa, is the centre of all utility services and operations and houses 22 per cent of the population. Its coastal location makes its infrastructure and government assets vulnerable to the storm tides and strong winds that characterize tropical cyclones. Urban growth in Apia and its adjoining areas is predicted to continue to rise. The unplanned expansion of Apia cannot be ignored as environmental problems are already increasing. Such problems include: domestic and industrial waste disposal; overcrowding and lack of privacy; flooding caused by building on flood-prone and poorly drained lands; dead animals such as cattle and dogs; reclamation of coastal lands and mangrove destruction; septic-tank effluent flowing into the groundwater and coastal ecosystems; and, impacts of urban areas on water quality and land resources. Several villages now form one linear strip of urban development between Apia and Faleolo. The same pattern is also evident in Salelologa. People living here have access to urban services, transportation, electricity and telecommunications. But centralizing services in Apia, and increasing coastal populations, means that infrastructure and communities are vulnerable to sea-level rise and extreme weather events such as tropical cyclones.

The Planning and Urban Management Act 2004 provides legal grounds to implement an integrated system of urban management and planning for sustainable development and environmental management. Zoning typically specifies the areas in which residential, industrial, recreational or commercial activities may develop. But the Act needs to consider developments/structures that:

- are adaptable, flexible and movable;
- can cope with changing sea levels;

- account for water availability;
- are resilient to extreme storm events and high temperatures for extended periods.

This project aims to integrate climate-change policies and methods into all Sustainable Management Plans at national, regional, district and site specific levels, and to mainstream climate-change policy into the planning and urban management agency's plans, policies and development-assessment reports.

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