


Population Dynamics and Climate Change

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Foreword

Climate change is already impacting populations and ecosystems around the globe and threatens to set back development efforts by decades, profoundly affecting us all. The defining challenge of the 21st century is to combine a rapid reduction in poverty and inequality with a rapid reduction in global greenhouse gas emissions. Meeting this challenge requires an understanding of how the size, structure and dynamics of human populations influence, and are influenced by, our changing climate.

In June 2009, UNFPA (the United Nations Population Fund) and IIED (the International Institute of Environment and Development), in collaboration with UN-HABITAT and the Population Division of the United Nations Department of Economic and Social Affairs, organized an Expert Group Meeting on Population Dynamics and Climate Change. This volume is a product of that meeting and of a broader research, policy and advocacy collaboration between UNFPA and IIED on issues of population and development.

In the coming years, the global community will build on the commitments defined at the 15th Conference of the Parties to the United Nations Framework on Climate Change Convention (COP15) both to forestall future climate change and to adapt to the current and future impacts that greenhouse gas emissions have already wrought. UNFPA and IIED are committed to strengthening data collection and research in the areas outlined in this volume and to supporting greater global, regional and national investment in collaborative work on the linkages between population dynamics and climate change.

Significant efforts and resources are being applied to the technological, infrastructural and financial challenges to finding solutions to climate change. Yet the need to focus on those who are most vulnerable to current and future impacts—women, children, older persons and the poor in developing countries—remains pressing. In working on how population dynamics are linked to emissions, vulnerability and resilience to climate change, UNFPA and IIED hope to contribute to the design and implementation of national policies supporting the well-being of present and future generations.

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Introduction[1]

Population matters for climate change. Incorporating population dynamics into research, policymaking and advocacy around climate change is critical for understanding the trajectory of global greenhouse gas emissions and developing and implementing adaptation plans, and thus to global and national efforts to curtail this threat. The papers compiled in this volume attempt to broaden and deepen understanding across a wide range of population-climate change linkages. Taken together, they provide a substantive and methodological guide to the current state of knowledge on issues such as population growth and size and emissions, population vulnerability and adaptation, migration and urbanization and the data and analytical needs for the next stages of policy-relevant research.

Population issues have historically been an important focal point in the debate about global environmental change in both policy and research circles. In the last 15 years, climate change has risen to the top of the international environmental agenda. Unfortunately, this has coincided with population issues fading in the discussion. This has meant that the links between population dynamics and climate change are often ignored, resulting in incomplete assessments of the causes and consequences of climate change. Where population issues have remained at the forefront, attention has been limited to population size and growth.

For instance, in its projections to date, the Intergovernmental Panel on Climate Change (IPCC) only incorporates global population size and growth into its emissions projections, without disaggregating or differentiating between the emissions levels of different social or demographic groups. Assessments of the current and future impacts of climate change include detailed models of where sea level rise will occur, how precipitation patterns may change and what the consequences will be for agricultural production and infrastructure. Yet the questions of which populations will be affected, in what ways and how they can best adapt using the resources at their disposal are often missed. When population issues are discussed in policy and media reports related to climate change, it is frequently in the form of worried statements about the pace of population growth (particularly in the developing world) or the potential for massive climate-induced migration.

There is a clear need for a broader, more nuanced, evidence-based perspective on how consideration of population dynamics can inform climate change responses, including both mitigation and adaptation. On 24-25 June 2009, UNFPA (the United Nations Population Fund) and the International Institute for Environment and Development (IIED), in collaboration with UN-HABITAT and the Population Division of the United Nations Department of Economic and Social Affairs, hosted an Expert Group Meeting on Population Dynamics and Climate Change for this purpose. The presentations and discussions at this meeting, by renowned population and climate-change experts, articulated the need for policymakers at the global, regional and country levels to incorporate population dynamics into their climate-change responses. Most of the papers in this volume are drawn from and build on the presentations made at that meeting. The remainder of this introduction summarizes the contributions, both consensus and contested, of the Expert Group Meeting and the papers in this volume and points to the way forward for integrating them into global and country-level climate-change responses.

Population Dynamics and the Drivers of Climate Change

The first two chapters provide overviews of the relationships between population dynamics and climate change from two somewhat different perspectives. Both point to the challenge that continued population growth will pose. The fact that, according to the latest United Nations projections, the world's population had reached 6.8 billion in July of 2009, and that it continues to grow by an additional 78 million people a year, is highly relevant to understanding environmental change. Barring natural or man-made cataclysms, world population will continue to grow in large numbers during the first half of this century. According to the latest United Nations projection, world population could theoretically reach a high of 10.5 billion, or remain as low as 8.0 billion, by 2050.

Still, the relationship between population size/growth and greenhouse gas emissions is complex. In Chapter 1, George Martine situates the challenge of population growth within the context of broader development trends, including changes in consumption and levels of urbanization. He warns against the temptation to view family planning programmes, and their potential for reducing population growth, as a panacea for mitigating climate change. He also points out that while urbanization is sometimes blamed for driving climate change, it can not only reduce population growth, but, if well planned, it can reduce the per capita greenhouse gas emissions associated with any given economic output.

In Chapter 2, Hania Zlotnik emphasizes a very different risk: that the decline in international support for sexual and reproductive health services (SRH) has already resulted in an increase in unintended fertility, and that continued neglect could greatly amplify a range of population-related challenges, including climate-change mitigation and adaptation. While these two chapters do reflect some differences of opinion over the capacity of family planning programmes to lower fertility and eventually lower greenhouse gas emissions, taken together they clearly demonstrate the importance of taking a balanced approach to issues of population dynamics and climate change. Family planning programmes should be treated neither as panacea or pariah.

Moreover, as both David Satterthwaite in Chapter 3 and George Martine point out, changes in population growth among poor groups will have little impact on emissions even over the long term absent significant poverty reduction. The per capita emissions of different individuals and population groups vary by orders of magnitude. When understanding and projecting emissions into the future, differences linked to population composition and distribution must be taken into account. And when projecting the impact of population stabilization on emissions, differences in consumption levels are of utmost importance. New modelling processes are incorporating variations by age and spatial distribution in order to better understand the contribution of different scenarios of future population growth to global emissions. It is also crucial to integrate differential consumption, as well as production, into these modelling exercises.

Further, as David Satterthwaite argues, an understanding of how the situation will evolve in the face of fast-paced urbanization, particularly in Africa and Asia, requires a very careful analysis of what urbanization actually is and what it means for the production and consumption dynamics that link population and emissions. In order to understand how future population growth will reshape the landscape and the level of risk, it is important to develop models of city population and spatial growth. Using currently available materials, it can be shown that one empirically powerful influence on city growth is urban fertility rates. A significant fraction of urban fertility is either unintended or unwanted. This implies that efforts to reduce fertility through voluntary family planning programmes may ease the urban adaptation burden in the future.

Development is essential to reduce poverty and inequality but, under present models, development will exacerbate global climate change (GCC). Countries currently considered 'developed' account for the bulk of greenhouse gas emissions to date, and, as countries 'develop', their per capita contributions increase. As a result, development itself has become a threat. This consequence of current development models must be addressed urgently and effectively in a way that will benefit the poor and not block their path to social and economic advancement or to environmental justice. Indeed, combining a rapid reduction in poverty and inequality alongside a rapid reduction in the global emissions of greenhouse gases looks to be the defining challenge for the 21st century.

In sum, provided poverty is addressed, and measures are taken to ensure that family planning programmes are used to enhance (and not to constrain) human rights and reproductive health, family planning can become an important and integral part of climate-change adaptation and, in the long run, mitigation. Improved access to SRH (including family planning) within a rights perspective is essential for individual welfare and accelerates the stabilization of population growth. Family planning programmes have, in the past, contributed to declining population growth rates, and slower population growth in some countries has bought more time to prepare adaptation plans for the coming impacts of climate change. Given the nature of demographic inertia, as well as the differences in development levels and consumption patterns, family planning programmes do not, however, provide a quick means of reducing emissions.

Urbanization

Almost all population growth in the foreseeable future will occur in urban areas, mostly in developing countries. The linkages between population growth, urban population growth and emissions involve several multiplicative factors, each of which varies significantly among population sub-groups within countries, across countries and over time. As David Dodman argues in Chapter 4, there is some evidence of the links between urban density (compactness of form, absence of sprawl) and mitigation. Much depends on initiatives taken by mayors, community and neighbourhood organizations and other local leaders in relation to processes of urban growth and urban organization.

Urban centres not only concentrate a growing share of the people and activities driving climate change, but also the people and activities that must adapt to the consequences of climate change. Whereas the emission of greenhouse gases is spatially blind, in that the effects are the same no matter where in the world the emissions take place, the same is not true for the impacts of climate change, which tend to be localized. Thus, for example, the climate-related risks for a settlement located on a coastal delta are likely to be very different from those for a settlement in high-elevation drylands. In Chapter 5, Deborah Balk and colleagues draw upon a newly-assembled database on city population size for several thousand cities in the developing world and employ a spatial analysis to assess their location, density and growth in relation to two ecozones likely to face distinct climate-related hazards: the low-elevation coastal zone and drylands. In addition, while the poor are not uniformly vulnerable to the impacts of climate change, the intersection of geography and poverty is a major predictor of risk. The chapter also illustrates how more detailed information on poverty can be used to assess particular vulnerabilities in specific cities.

Migration

Migration is caused by a number of factors; environmental change is one that has existed for a long time, but it has been increasingly highlighted because of the current and future impacts of climate change. In Chapter 6, Cecilia Tacoli argues that while there are some legitimate concerns about climate-induced migration, alarmist predictions suggesting that such migration will be a major negative consequence of climate change are misleading. The scale of the impacts is highly uncertain, and migration is not inherently negative. Mobility will in all likelihood increase. Based on past experience however, short-distance and short-term movements will predominate. These will be key elements in strategies of adaptation to climate change, but the poorest will find it difficult to move, and this should be at least as much of a concern for policymakers as the possibility that large numbers of people will migrate.

In short, migration and mobility in the context of climate change need not be the problem, but can become part of the solution. For this to occur, however, policies need to accommodate and support migration and mobility by strengthening local governments and the institutions that can contribute to the reduction of cumulative vulnerabilities. Scott Leckie, in Chapter 7, argues for the need to develop better legal frameworks to support people who are displaced by the impacts of climate change.

Failure to support rural populations in adaptation will help produce crisis-driven movements that increase the vulnerability of those forced to move, as they leave behind homes and assets and lose valuable social networks and family ties. In some countries, refugees fleeing conflicts and disasters are a large part of the urban poor, and it can take them a long time to integrate into local communities and find employment and shelter. Failure by national governments and international agencies to recognize and support adaptation, including mobility and migration, for the poorest and most vulnerable households could result in forms of migration more damaging for both the migrants and the receiving communities.

Vulnerability

It is impossible to understand and reduce vulnerability without taking population dynamics into account. From acute, climate-related events like storms and floods to long-term shifts in weather patterns and sea level patterns, the impacts only become clear through an understanding of who is at risk, what the risks are to people rather than just to places and how these risks vary within and across populations. Vulnerability is unevenly distributed between men and women and between the young, the middle aged and the elderly. Sheridan Bartlett, in Chapter 8, reviews the specific vulnerabilities of children to climate change impacts and points out that children are not only a very large proportion of those who are most vulnerable, but also those for whom the effects of such vulnerability can extend over a very long term. Gotelind Alber, in Chapter 9, examines how the impacts of climate change exacerbate gender disparities and argues that, to be effective, both adaptation and mitigation policies need to address underlying patterns of social inequality.

Projecting vulnerability to the immediate and longer-term health impacts of climate change requires a holistic model that takes into account social, demographic, economic, political and other factors. In Chapter 10, Sari Kovats and Simon Lloyd review the wide range of health risks that climate change is likely to exacerbate and how climate change will increasingly influence the shape of health interventions. Chapter 11, by Clive Mutunga and Karen Hardee, examines the links between reproductive health and adaptation through an assessment of the coverage of these issues in National Adaptation Programmes of Action (NAPAs).

As indicated in these and later chapters, it is clear that poverty is inextricably linked to climate change vulnerability: The impacts of climate change destabilize the livelihoods of the poor in particular, and poverty increases the challenges of adaptation in the context of sustainable development.

Data and Measurement

One of our foremost challenges in understanding the linkages between population dynamics and climate change is in identifying, collecting and integrating data. United Nations agencies must advocate for responses that include the characterization of population trends and support the data collection, research and analysis at the global and country levels necessary to ensure that those responses are evidence-based. José Miguel Guzmán, in Chapter 12, shows that census data provide an insufficiently utilized source of information for the analysis that will improve both mitigation and adaptation efforts. The 2010 round of censuses provides an exceptional opportunity to exploit the potential of this source of information, but doing so will require urgent and effective efforts at the international and national levels. Encouraging and supporting the timely release of census data is an important role for global institutions.

Deborah Balk and her co-authors demonstrate in Chapter 13 that an essential ingredient in constructing the evidence base for urban adaptation is the availability of population and socio-economic data for finely disaggregated administrative and political units. These data provide a frame over which climate-related risk maps can be laid to produce estimates of the number of people, the percentage poor and numbers of the poor by jurisdiction and neighbourhood. The effort to assemble such data must begin with the processing of national censuses into small-area units. This should be conducted in a manner sensitive to ecosystem and other bio-geophysical parameters, with the drylands and low-elevation coastal zones serving as examples. It is also necessary to consider the utility of the most local analysis, given that many impacts of climate change are still in the future and urban areas undergo constant change.

As Hy Dao and Jaap van Woerden point out in Chapter 14, United Nations support of improved data streams and technical assistance is essential to this kind of research. The authors also underscore the myriad challenges of definitional issues in climate-change analysis, including problems of scale—global, regional, national and community—definitions of coastlines, boundaries and expanses, omissions in the production and dissemination of data and measurement of consumption-based versus supply-based emissions, among others.

Incorporating Population Dynamics into Post-Copenhagen Climate Change Responses

Several points are of particular importance when assessing the links between population dynamics and climate change, some of which are addressed directly by the papers in this volume. First, population size and growth matter for emissions projections over the long term, though the magnitude of the effect is difficult to estimate. This difficulty is associated with many factors, in particular the complex interrelationships among economic growth, production, consumption and population growth, and also because of the extent of the data needed for accurate modelling. Nonetheless, there is consensus in the scientific community, spurred by new modelling efforts that incorporate population structure, composition and distribution together with variations in consumption and production, that slower population growth will lead to a decline in long-term emissions. These effects depend not just on the total of number of people, but also on age structure, household composition and spatial distribution.

Second, there are many reasons to pursue a rights-based approach to reproductive health and decreasing fertility; the 1994 Programme of Action of the International Conference on Population and Development describes these in detail. Better adaptation to the impacts of climate change is yet another reason, as addressed by Clive Mutunga and Karen Hardee in this volume. Family planning programmes can also be expected to help mitigate climate change in the long run, but it is important that governments not be given financial incentives to achieve reductions in their countries' population growth, given the risk of a return to the oppressive population targets and controls that several countries adopted in the past. Therefore, funding mechanisms for reproductive health should not be coupled directly to emissions targets, though coupling them to adaptation is both appropriate and essential.

Third, there are many components of the link between population dynamics and climate change beyond population size and growth. As this volume shows, the issues of health, gender inequality, migration and displacement and urbanization all link population dynamics with climate change and need to be incorporated in planning and implementing global and country-level responses. These issues are particularly relevant in the development of adaptation plans, including in assessing the costs of adaptation.

At the country level, United Nations agencies acting together through the Delivering as One initiative, in concert with partners like IIED, can provide a new structure for engaging more effectively and holistically on climate change. Still, much work needs to be done to ensure coordination among agencies and with governments and partners from civil society. Both the Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change and the NAPAs provide additional entry points to integrating population dynamics into responses, since many of them recognize the associations between population growth and composition and vulnerability.

Substantial resources are being dedicated to research and policy efforts to mitigate climate change and support adaptation to the current and future impacts of greenhouse gas emissions. Yet the lack of consideration of population dynamics hampers understanding and development of stronger, more effective solutions to the challenges climate change poses. In 2010 and beyond, as the world adjusts to a new climate-change agreement, and as the need for action heightens every day, it is our hope that this volume will help to address one of the most significant gaps in the global response to this time.

Note

1 The editors wrote this introduction with contributions from participants in the Expert Group Meeting on Population Dynamics and Climate Change.

1

Population Dynamics and Policies in the Context of Global Climate Change

George Martine

Introduction

Interest in demographic dynamics and their interactions with other mediating factors on potential environmental threats is resurgent in the wake of increasing concern about climate change. Most discussions of this global menace include some mention of population processes, yet the treatment of these is frequently incomplete or incorrect. Attention is generally focused on population growth, widely portrayed as a major driver that could easily be reduced. 'Urbanization' is also repeatedly cited as an important driver of increasing emissions, but without recognition of its potential contribution to mitigation. Significant changes in population composition and their implications for mitigation and adaptation receive scant attention outside the demographic community. Simplistic assumptions about demographic trends and their impacts weaken emissions scenarios and lead to misleading policy suggestions.

This chapter will summarize some of the key issues involving the relationship between global climate change and each of the three major components of demographic trends: growth, distribution and composition. Each of these sections will conclude with a brief discussion on implications for population policy. Given space limitations, this chapter will focus mainly on the interface between demographic processes and mitigation.[1]

Perspectives on Population Growth and Environmental Change

Few panaceas generate as much popular backing in developed countries as the notion that: a) a reduction in population size and growth would go a long way towards solving the world's major problems, including those related to climate change; and b) this reduction could be easily achieved through family planning programmes. Thousands of variations on this message—which has been dubbed "The Northern Perspective" (Hummel et al., 2009)—can easily be found in internet documents spanning a variety of substantive fields.

Despite the pressure of the Northern Perspective, the Intergovernmental Panel on Climate Change (IPCC) has downplayed the importance of population policy in mitigation and adaptation efforts—either because of apprehension about political repercussions in developing countries or from a failure to perceive its vital implications. Population projections constitute, implicitly or explicitly, the backbone of greenhouse gas (GHG) emissions scenarios. The 2007 IPCC report repeatedly mentions 'population', but without getting into the specifics of 'population dynamics' and, generally, with negative connotations (Metz et al., 2007).

There is thus a need for a more penetrating understanding and for a better balance in considering the role of demographic dynamics on Global Climate Change (GCC). The Northern Perspective overstates its case for population control, while the IPCC understates the significance of demographic factors and policies. Viewed in perspective, this gap reflects long-standing misapprehensions and discrepancies concerning the actual significance of population dynamics for environmental change. The population/environment debate has long been fraught with ideological overtones and substantive oversimplifications. A more discriminating look at the strengths and limits of population programmes, as well as a better understanding of other population dynamics, are needed in order to fill out the slate of population policies that are germane to global climate change.

Population growth, economic growth and GHG emissions

A population's size and rate of growth fundamentally affects the dimension and gravity of environmental problems through efforts made by countries to achieve 'development'. In the current predominant mode of civilization, and under present technological and environmental control levels, both population and economic growth are threatening. If the per capita consumption levels of the demographically small and slow-growing developed countries were to be reached by some of the large and/or rapidly growing countries under the same technological and environmental control conditions, the serious environmental problems of Planet Earth would inevitably take a quantum leap. As has repeatedly been demonstrated, many more planets would be needed to provide the resources that would allow the rest of the world to attain the same standard of living currently enjoyed by industrialized countries.

World population experienced its fastest growth in history during the second half of the 20th century, swelling from 2.5 billion in 1950 to 6.1 billion in 2000, as shown in Figure 1.1. However, this increase was smaller than the growth in world GNPP during the same period and much smaller than the fourfold increase in carbon emissions. Global climate change in the 21st century will depend on the interaction of these three trajectories.

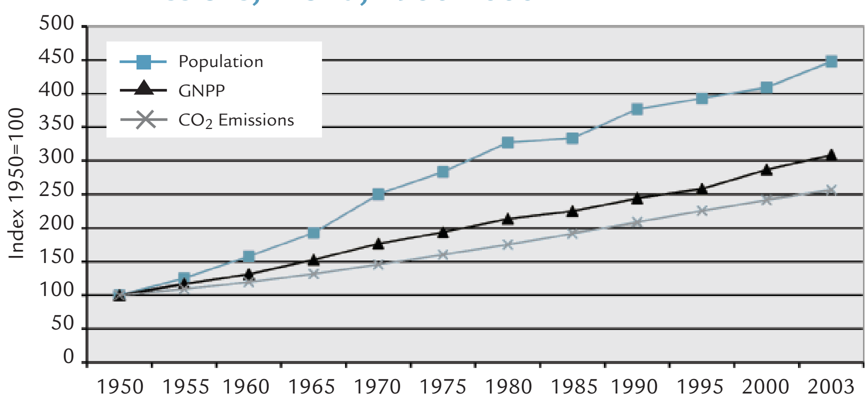
The easiest to foresee is that in the domain of population: Demographic processes have a built-in inertia that determines short- and mid-term outlooks more predictably than trends in the economic or environmental fields. Nevertheless, the art of population projection is not an easy one, and recent shifts in fertility-level trends have made it even more capricious. Unexpected transformations have radically altered traditionally expected patterns, disrupted customary cleavages between groups of countries and altogether modified our traditional understanding of demographic processes.[2]

Over the previous half-century, most countries could easily be classified into tidy compartments: Developed countries had high incomes and low fertility while poor and developing countries had low incomes and high fertility. These traditional (though somewhat misleading) categories linking development levels to population growth rates have lately become blurred. Widespread and unexpectedly rapid declines in birthrates have been registered in the developing world, including much of Asia, Latin America and the Middle East. Previous scenarios of 'population explosions' are now restricted to most of sub-Saharan Africa plus a few other isolated countries (Afghanistan, Palestine, Timor Leste and Yemen) that still conform to the traditional mould of high fertility and high poverty.

On the other hand, the list of lowest-low fertility countries has shrunk noticeably in recent years (Myrskylä et al., 2009). Only Russia and the Eastern European countries continue to have low and declining below-replacement fertility. Contrary to all expectations, Northern Europeans are having more babies, with several countries now anticipating steady population growth through the middle of the century. Does this signal a regional rebound in fertility rates? Possibly, but not necessarily: A previous rebound was experienced in the Nordic countries where the total fertility rate rose from 1.7 in 1985 to 2.0 in 1990; however, by the end of that decade, fertility levels had fallen to 1.85 (Lutz et al., 2005, in Smil, 2008, p. 97). By contrast, in the United States—with by far the world's largest economy and bloc of consumers—the combination of immigrant and native reproductive patterns has boosted vigorous fertility rates that are likely to remain high in the foreseeable future.

Meanwhile, several developing countries now have the type of low fertility rates that until recently were found only in high-income countries. The Chinese

Figure 1.1 Evolution of Population, GNP Per Capita and CO_2 Emissions, World, 1950-2000



Sources: Population data from United Nations, 2008b; GNPP data from Maddison, 2004; and CO_2 emissions from Marland et al., 2007.

decline has been well publicized, but Iran, among others, has experienced an even faster decline over recent decades. Brazil has attained fertility levels that are lower than those of France, thus well below replacement level. Conversely, a doubling of population is anticipated in the United States.

In the midst of these diverse and confounding trends, aggregate world population—the main focus of interest over the last 60 years—continues to increase, but at a decreasing rate and volume. The fastest annual rate of increase occurred in the 1965-1970 period (2.02) and has been decreasing ever since. The largest annual increments in population occurred in the 1985-1990 period, when some 89 million people were added every year. However, levels of absolute increases have also slowed. Overall, according to the latest United Nations projections, world population reached 6.8 billion in July of 2009 and is currently increasing at a rate of 78 million per year (United Nations, 2009, p. 11). The bottom line is that, barring natural or man-made cataclysms, world population will continue to grow in large numbers during the first half of this century.

Policies in relation to population growth

Whatever one's starting point, the threat to global environmental security posed by this vastly growing population simply cannot be dismissed. Practically any possible environmental challenge facing humankind today, from ozone depletion to waste disposal, is made more difficult by a larger population size. However, this broad perception is insufficient to characterize the actual influence of population dynamics on environmental outcomes in general and on climate change in particular. A more discriminating perspective needs to consider:

- the limits of what can be achieved through efforts to reduce population growth and size;
- the effect that such a reduction can have on mitigation of climate change;
- the significance of other ongoing demographic processes.

Importance and limitations of family planning programmes

A large proportion of the world's women still do not have access to the means that would allow them to have only the number of children they desire (UNFPA and Alan Guttmacher Institute, 2004). There is even a substantial gap between actual and desired family size among the fastest-growing demographic groups in developed countries. It is of considerable significance that the 2.5 billion difference between the United Nations' highest and lowest projections is the result of only a one child per woman difference in world fertility. That being the case, human-rights-based policies that empower women and address unmet needs for reproductive health services—whether in developed, developing or least developed countries—would have an important impact on reducing the rate of population growth and thus on the eventual size of world population. While giving people, especially women, more control over their lives, this would also have critical longer-term impacts on climate change. In this light, everything possible should be done to provide women with the means to achieve their desired family size.

However, it should be clearly understood that addressing the issue of family planning needs effectively will not give humankind a reprieve from its obligation to face the more critical environmental challenges posed by the prevailing civilization's model of 'development'. Both demographic and environmental outcomes are linked to development processes that occur within particular historical contexts. An exaggerated focus on a-historical simplifications that do not take into consideration the complexities of the 21st century development scenario, nor their different implications for distinctive social contexts, favours inadequate policy suggestions.

Part of the reason that worldwide attention is increasingly focused on the population question stems from its painless simplicity. Attacking environmental issues from a demographic standpoint seems immensely easier than trying to deal with the causes of global environmental damage that are rooted in our very model of civilization. However, the two approaches cannot be expected to have comparable effects. Suggesting cutbacks in consumption when 'happiness' itself is predicated on having access to more goods is an extremely unpopular approach and threatens the very foundations of 'progress' and 'well-being' as they are defined today. By contrast, efforts to change 'irrational' and 'obsolete' reproductive patterns are 'obviously' much simpler. Common sense seems to indicate that people (especially poor people) would be better off with fewer children, and, if they did have fewer offspring, both society and the environment would be better off. However, the results of this change could be considerably less incisive than generally expected.

The actual magnitude of the impact that future fertility declines will have on the mitigation of climate change is far from being proportional to the number of people who are 'not born' under a scenario of rapid fertility decline. Enormous differences in social organization and in consumption patterns between regions and social groups translate into highly differentiated impacts of additional numbers.

Moreover, the practical ability to 'deal with the population problem' through family planning programmes is overestimated. Under the threat of climate change, the traditional view of the population establishment—that fertility declines as a result of family planning programmes and that it is therefore urgent to intensify such programmes in high-growth countries—has made a resurgence. However, this perspective overlooks well-documented arguments that rapid reductions in fertility depend at least as much on speeding up economic development and social transformations, as well as on empowering women and meeting individual's needs in sexual and reproductive health (see, for instance, Demeny, 1992 and 1994; Sen et al., 1994; Presser, 1997).

Over the last few centuries, population has grown rapidly as a result of some startling improvements in living conditions that generated a reduction in mortality. By the same token, fertility has recently declined significantly in most regions of the world in response to the profound socio-economic transformations associated with many different patterns of development. While spectacular declines in fertility have been facilitated by family planning programmes, such as those in China, Indonesia and Iran, underlying social transformations in each of these countries were also critical.[3]

The comparably rapid decline of fertility in Brazil was not effectively supported by any large-scale family planning programme but was largely driven by social transformations—including urbanization—that prompted people to use any means at hand to limit the number of their offspring (Martine, 1996). Meanwhile, several other countries with large-scale family planning programmes spanning several decades have experienced very slow and deliberate fertility declines. Fertility has also decreased in some poor countries or regions having exceptional social and institutional structures, such as in Kerala, India, but this only reinforces the lesson that some minimal social improvements are essential in order to motivate people to have a smaller number of children (Martine et al., 1998).

In brief, family planning programmes alone, without some minimal social transformation that motivates people to perceive that limiting fertility would yield some increment in well-being, and that empowers women to take control over their lives, are unlikely to reduce fertility rapidly. This is especially true in countries that still have a predominantly rural population. Throughout history, rural families have had more children in order to work the land. Practically all the least-developed countries still have a large majority of their population residing in rural areas, where family planning programmes are more difficult to implement and have understandably had a lesser impact—unless some form of coercion was applied.

Given the association between development and fertility decline, even a reduction in population growth does not necessarily result in reduced consumption. Not to be overlooked here is the fact that when development—often quickened by urbanization—unfolds sufficiently to motivate people to reduce their fertility, it inevitably increases their consumption levels as well. Thus, while it is clear that fertility decline is absolutely essential for sustainability in the long term, it is only the starting point for more effective measures addressing consumption.

In short, the Northern Perspective's approach to mitigation through family planning has to be situated in the context of the world's updated demographic profile, as well as its stage of development. The timing and magnitude of the probable effects of a fertility reduction on climate change will vary considerably according to the current demographic and development situation of each country. On the one hand, reducing fertility in poor and least-developed countries—where fertility levels are still invariably high—would bring important social benefits in the short run and, perhaps most important, help to decrease the vulnerability of these populations to the effects of climate change. However, since their consumption levels and their impact on emissions are still comparatively low, a reduction in their population growth will not represent a major boost to global mitigation efforts in that time span. Moreover, the social transformations that are minimally necessary to motivate the adoption of family planning are likely to have an equally significant but opposite impact on increased consumption.

In the medium and longer run, given the inertia of demographic processes (i.e., the fact that populations continue to grow long after they have reached replacement fertility) and the hope that all countries will move quickly out of poverty and under-development, it is important for global mitigation efforts to achieve slower population growth now rather than later. Should they reach the recently successful development levels—and thus increased consumption—of such countries as China and India, having smaller populations will clearly be significant for GCC over the longer range.

On the other hand, reducing fertility in developed countries would have a greater effect in the short term on reducing consumption and emissions than it would in poor countries. In purely logical terms, this is where a major fertility-reducing effort would seemingly have the greatest impact at this time. However, in practical terms, it would obviously be more difficult to attempt to limit fertility in this group of countries than it would be in poorer countries. With the glaring exception of the United States, most industrialized countries have actually found themselves obliged to make energetic efforts to *increase* their birth rates. Such policies, aimed at stimulating fertility, are grounded in vital national interests inspired by demographic concerns such as diminishing size, reduced labour force and population ageing, as well as in other less tangible issues related to national identity and sovereignty. Official and popular reactions to news of increased birth rates in these countries have bordered on the jubilant. Under these circumstances, it is hard to envision that great enthusiasm would be generated for fertility reduction efforts within these countries.

Secondly, it must be observed that even rapid fertility declines would not quickly produce the stabilization or reduction of population sizes. Given the effects of demographic inertia, a country's population continues to grow in absolute numbers for some decades after it has reached below-replacement fertility. Thus, China reached a below-replacement level of fertility in the early 1990s, but its population is expected to grow by an additional 320 million from that point on before it finally stabilizes and starts to decrease after 2035. Worldwide, the majority of population growth today is due less to current fertility patterns than to imbedded demographic inertia, that is, the result of the fertility and mortality patterns of previous generations. This inertia results in a time lag of several decades between the initial reduction in fertility levels and any population decline. It has been estimated that over half of world population growth during the first half of this century will be attributable to inertial factors (National Research Council, 2000). The contribution of inertial growth would be even larger if sub-Saharan countries were discounted from these calculations.

Such sobering observations on the limitations of endeavours to achieve rapid population stabilization should not, however, dampen ever-greater efforts to empower women and to provide them with access to family planning services in the framework of high-quality reproductive health services. Even inertial growth could be reduced if age at marriage was postponed and the age at conception of the first child was delayed (Bongaarts, 2007). However, these modifications in marital patterns themselves require important cultural changes that may not be forthcoming.

Thirdly, the limitations of the 'demographic solution' must be made clear. Sheer numbers do not tell the whole story. The world is already on the threshold of a major climactic threat, with or without population growth. Family planning simply does not have retroactive capabilities. Even if humankind failed to produce a single baby during the next generation, its quality of life on Planet Earth would still be endangered by climate change. The latest United Nations projections indicate that the world could have as few as 7.96 billion people and as many as 10.46 billion in 2050 (United Nations, 2009). No one would dispute the fact that this difference of 2.5 billion could greatly aggravate global environmental problems. Nevertheless, it is also true that a world population of 7.96 billion could actually inflict greater damage on the global environment than one with 10.46 billion, if the former achieved the production and consumption patterns of industrialized countries.

In short, efforts to limit fertility through family planning programmes, in the absence of some measure of development or social transformation, are not likely to work from a demographic standpoint. Without drastic changes in the production and consumption patterns of our civilization, they would also not work from an environmental standpoint.

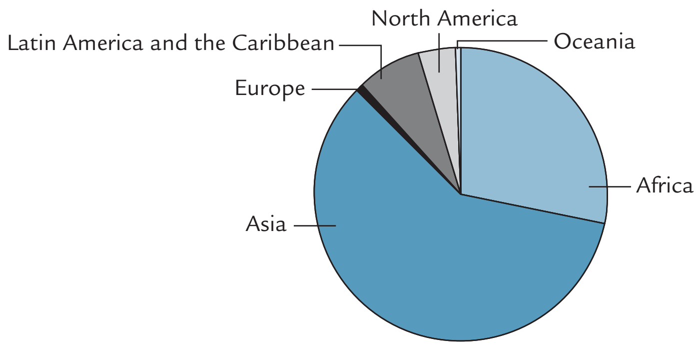
Urbanization and the Sustainable Use of Space

As noted, public attention to demographic factors in environmental change has focused almost exclusively on population size and rate of growth. However, population dynamics also involve the changing distribution of population over space, as well as its evolving composition over time. The spatial dimension of population and its relation to environmental dynamics warrants much greater attention than it has received so far. The battle for a sustainable environmental future is being waged primarily in the world's cities where population, economic activity and environmental issues are increasingly concentrated.

Contrary to standard belief, higher levels of urbanization can constitute a positive factor in dealing with population/environment problems. As observed in a recent issue of *Science*: "Cities themselves present both the problems and solutions to sustainability challenges of an increasingly urbanized world . . . large urban agglomerations are fonts of human ingenuity and may require fewer resources on a per capita basis than smaller towns and cities or their rural counterparts" (Grimm et al., 2008, p. 756). Fulfilling the potentialities of cities for long-term sustainability, however, will require changes in approaches and policies. Local decisions have far-reaching effects, and, conversely, climatic or ecosystem changes may have a local impact. Poorly managed urban development can have destructive local and even global consequences.

By comparison to the increasing diversity in fertility patterns, the spatial distribution of population is marked by an inexorable and universal trend towards urban concentration. For the first time in history, more than half of all human populations are now living in towns and cities. Even more important, at the aggregate level, almost all population growth is occurring in cities: *Population growth issues are thus primarily urban issues.* The number of urban-dwellers will continue to rise quickly, reaching almost 6.2 billion people in 2050. About 95 per cent of this future growth will be concentrated in developing countries, especially in Africa and Asia (see Figure 1.2). These two lag far behind other continents in terms of urbanization levels, but the present and future growth in absolute numbers of urban people in these regions is massive and unprecedented.

Figure 1.2: Proportion of World Urban Growth, By Region, 2010-2050



Source: United Nations, 2008a.

This transformation will have enormous implications for climate change, given the increasing concentration and magnitude of economic production in urban localities, as well as the higher living standards that urbanites enjoy by comparison to rural populations. Urban concentration will also be critical for mitigation and adaptation efforts in view of the greater vulnerability of urban populations to some of the more hazardous consequences of GCC.

For the most part, however, the significance of urbanization and urban growth for environmental change and, in particular, for climate change, has not been appropriately depicted. The IPCC 2007 report, for instance, refers to urban areas on several occasions, often in connection with 'land-use change', and generally in reference to their role in stressing environmental limits, generating problems in services and infrastructure, aggravating health, food or other social problems or otherwise contributing to climate change. The special vulnerability of urbanites, especially in low-lying coastal zones or urban slums, is also highlighted. But nowhere are the inherent advantages of urban areas for mitigation mentioned nor their potential advantages for adaptation.

The IPCC's negative perspective on urbanization mirrors the dominant public and environmentalist perception, wherein cities are pictured as having an inordinate ecological footprint and making decisive contributions to global climate change. Traditionally, environmentalists have taken a dim view of urbanization and city growth. From the inception of the modern environmental movement, concern with the preservation of nature has focused attention on rural areas.

"Ecologists shunned urban areas for most of the 20th century, with the result that ecological knowledge contributed little to solving urban environmental problems" (Grimm et al., 2008, p. 756).

Within this context, cities have generally been viewed primarily as the locus of the critical environmental problems generated by the production and consumption patterns of modern civilization. Well-meaning approaches, such as the 'ecological footprint' measurements—initially focused on cities—have served to increase environmental awareness but, in the process, have also reinforced the idea that cities are the world's major environmental culprits, given the high concentration of energy use and industrial production in urban areas.

This stance is indeed commonplace today (see, for example, Dodman, 2009, p. 186). It is generally acknowledged that the two most important anthropogenic activities associated with urbanization that impact climate involve changes in land use and the increase in greenhouse gases. The following section focuses on land-use change; the relation between urbanization and GHG emissions is analysed in Chapters 3 and 4.

Land-use and land-cover change

Land-use changes are considered a first order climate forcing factor: Around 31 per cent of all greenhouse gas emissions are reputed to arise from the land-use sector (Scherr and Sthapit, 2009, p. 32). Although the changes in land use brought about by urban growth are routinely cited as a major factor in the growth of GHG emissions, the actual level of this impact appears open to question. In principle, "[r]eplacing natural vegetation with roads and buildings often decreases the surface albedo and alters the local surface energy balance, increasing sensible heat flux and decreasing latent heat flux" (Kueppers et al., 2008, p. 251). Although this effect has been verified with respect to local 'Urban Heat Islands' (UHI), the empirical evidence linking urban land use to regional or global climate change does not appear to be robust.

Initially, it appears that most studies over a larger land area find it difficult to distinguish the temperature impacts of urban land use from other land-use changes. One study estimated that land-use changes accounted for half of the observed reduction in the diurnal temperature range and an increase in mean air temperature of 0.27°C in the continental United States during the past century (Kalnay and Cai, 2003, p. 528). Another study on temperature changes in the United States covering a span of 40 years (1960-1999) corroborated verifiable changes in temperature that are attributable to land-use changes, but failed to distinguish between the effects due to urban growth from those derived from agriculture and deforestation (Cai et al., 2004, p. 2).

A study in the Zhujiang Delta of China did conclude that strong and uneven urban growth caused the land surface temperature to rise by 4.56°C in "the newly urbanized part of the study area" (Qian et al., 2006); however, it is not clear whether this refers to a UHI or a regional effect. In the United States as a whole, analyses of the impacts of urban land-cover change on climate change have apparently not yielded significant results—in the order of 0.006C/dec. and 0.015C/dec. (Cai et al., 2004, p. 1). One recent study concluded that ". . . urban areas show a large warming second only to barren areas" (Kalnay et al., 2008, p. 7) while another found that "[c]onverting natural vegetation to urban land-cover produced less pronounced temperature effects in all models, with the magnitude of the effect dependent upon the preexisting vegetation type and urban parameterizations" (Kueppers et al., 2008, p. 250). Part of the reason for these low correlations, the latter authors explain, is simply *the relatively smaller spatial extent of urban areas*.

In this light, it would seem critical to quantify the amount of land that is actually being converted to urban use.[4] At present, this quantity is not yet as enormous as seems to be generally assumed; however, it is important to examine how massive urban growth could change that situation in the future. Much improved estimates on the dimensions of the Earth's land area that is covered by urban localities are now available. These new sets of global databases on urban population and extent combine census data, satellite imagery and different methods of analysis in an integrated geospatial framework. Two of the best known recent studies based on such technologies can, for purposes of this chapter, be taken as the upper and lower limits of the area currently occupied by urban localities.

The Global Rural-Urban Mapping Project (GRUMP) (CIESEN, n.d.) estimates that urban localities occupied, in the year 2000, a land area of 3.506.656 km². This corresponds to about 2.7 per cent of the Earth's total land area, equivalent to less than half of Australia's total.[5] In light of current discussions among specialists, these figures can be considered as the upper limit of current estimates of urban land use.

The low estimate can be taken from a recent study commissioned by the World Bank (Angel et al., 2005). This focused *only* on cities having more than 100,000 persons, and, within them, *only on their built-up areas* (i.e., excluding green areas and other interstitial spaces). Using a sample of 120 cities worldwide, this study estimated that cities of 100,000 or more inhabitants contained 2.3 billion of the estimated 2.84 billion urban inhabitants in the year 2000. These urban inhabitants used up a total built-up space of 400,000 km² worldwide, equivalent to 0.3 per cent of the Earth's land area.

Assuming that the total population living in urban localities having less than 100,000 inhabitants (540 million) had an average density of 6,000 persons per square kilometre,[6] they would occupy another 90,000 km². Under such assumptions, the total built-up land area in all urban localities around the world would amount to 490,000 km² (400,000 + 90,000), or an area slightly smaller than Spain and less than half of 1 per cent of the Earth's total land area.

In short, approximately half of the Earth's population occupies an area equivalent to between 0.4 and 2.7 per cent of the Earth's surface, with the larger number reflecting all spaces within the perimeter of towns and cities and the smaller number measuring only the built-up areas of towns and cities. For present purposes, the exact figure is not an issue here since any number within this range would not seem to represent, in itself, a critical threat to the Earth's sustainability.

Although human settlements have so far taken up a relatively small fraction of the Earth's surface area, *future* land use has understandably raised some concern. The aforementioned World Bank study (Angel et al., 2005) shows that urban land areas are growing faster than ever because of a combination of absolute increases in numbers of people with a decreasing average density. The study observes that urban density in built-up areas has been declining for the past 200 years and that the reduction has been particularly rapid in recent years (Angel et al., 2005). This tendency towards declining density, combined with unprecedented absolute increases in the urban population, could greatly expand the land area of cities in the future.

At present, cities in the developing world occupy less space per inhabitant than in developed countries. In both developing and industrialized countries, average densities of cities have been declining rapidly: at an annual rate of 1.7 per cent over the last decade in developing countries and of 2.2 per cent in industrialized countries (Angel et al., 2005, pp. 1-2). Table 1.1 presents a scenario of urban land use between 2010 and 2050 under two assumptions: a) that urban density during that period would remain the same as it was in the GRUMP study (columns in blue); and b) that density would continue to decrease over those four decades at the same rate as it did during the 1990s in the World Bank study (last two columns). It is important to note that the urban land-use data which serves as a basis for these scenarios are those provided by the GRUMP analysis, that is, the estimate being considered here constitutes the upper limit of urban land use.

These numbers have to be taken as merely illustrative of broad tendencies within the bounds of the supplied scenarios, rather than as reliable projections. They do, however, serve to accentuate the fact that urban land use is likely to expand significantly in those regions that are expected to undergo massive urban growth in coming decades, notably in South-Central and Western Asia, as well as in North America. Nevertheless, even under the assumption of increasing sprawl (last two columns in Table 1.1), the increase in the amount of land is not extraordinary, and the proportion of all land that is urban in 2050 would still be less than 5 per cent worldwide. Moreover, if one uses the definition proposed by the World Bank study, in which only built-up areas are considered 'urban', the proportion of all land utilized by urban localities would be less than 1 per cent in 2050 (not shown).

Much could be done to lower these dimensions with urban planning that favours a more sustainable use of space. The good news is that most of the growth in Asia and Africa is still to come: This means that there is still an opportunity to make future growth more sustainable and more satisfying for the millions of poor people who will comprise this future urban boom. In order for this to happen, as has been argued recently by UNFPA (2007), policies and the orientation of planners with respect to inevitable urban growth must change radically.

Table 1.1: Scenarios of Urban Land Use, 2010-2050, By Region, According to Two Assumptions

Region	Urban Land in 2010 (Sq km)	Urban Land as % of Total in 2010	Urban Population in 2010 (in 000s)	Projected Population Growth 2010-2050 (in 000s)	Urban Land in 2050*	% of Total in 2050*	Urban Land in 2050‡	% of Total in 2050‡
Northern Africa	81,378	0.99	107,312	115,969	169,321	2.06	181,132	2.20
Sub-Saharan Africa	138,287	0.65	304,879	705,812	458,429	2.15	490,406	2.31
East Asia	401,045	3.53	757,180	421,689	624,395	5.50	667,949	5.88
South Central Asia	349,993	3.35	571,987	878,689	887,654	8.5	949,571	9.09
South Eastern Asia	96,874	2.17	286,579	275,001	189,834	4.25	203,076	4.55
West Asia	144,247	3.55	153,870	141,014	276,442	6.80	295,725	7.28
Eastern Europe	299,382	1.64	198,951	(21,732)	266,680	1.46	290,933	1.59
Europe (Remainder)	533,250	12.97	331,297	48,208	610,845	14.86	666,399	16.21
Latin America and Caribbean	526,991	2.59	471,177	211,374	763,404	3.75	816,654	4.01
Northern America	885,876	4.68	286,316	115,162	1,242,193	6.56	1,355,166	7.16
Oceania	49,211	0.58	25,059	12,188	73,146	0.86	79,798	0.94
WORLD	3,506,534	2.70	3,494,607	2,903,374	5,562,342	4.28	5,996,810	4.62

* Assumption 1: Land use per person will continue the same over the 2010-2050 period.

‡ Assumption 2: Land use per person will increase at rate of 1.7 per cent per decade in developing regions and 2.2 per cent in developed regions over the 2010-2050 period.

Sources: Current urban land use from CIESIN, n.d.; population projections from United Nations, 2008b.

Policy implications regarding urbanization and urban growth

The scale of urban growth that will be faced by the developing world in coming decades has no parallel in history. The world's urban population will show an increase of over 2.9 billion people between now and 2050, most of this in Asia and Africa. How, where and in what conditions such growth will occur will have a huge impact on poverty reduction as well as sustainability.

Contrary to prevailing feeling, densely populated urban areas can become an important ally for long-term sustainability and, specifically, in efforts to mitigate GCC. Cities are the primary font of environmentally favourable technological innovations. If well designed and administered, the compactness and economies of scale of cities can reduce per capita costs and energy demand, while also minimizing pressures on surrounding land and natural resources. High-density agglomerations can also be useful in avoiding such problems as deforestation and loss of biodiversity, while generally helping to optimize the rational use of resources and the provision of cost-effective environmental services. Dispersion of existing population would, in most cases, exacerbate pressures on ecosystems. Moreover, urbanization itself is a powerful factor in fertility decline. Historically, fertility decline has always occurred first and quickest in cities, making urbanization a potent ally in fertility reduction efforts.

Longer-term urban sustainability depends on the ability of policymakers to take a broader view of the utilization of space and to link local developments with their global consequences. Developing and developed countries face different sets of challenges and opportunities. The one advantage that potentially benefits developing countries is that much of their urban growth is still to come, giving them the opportunity to make more sustainable use of space at lesser human and financial cost. Taking advantage of this opportunity, however, will require a radical change in the anti-urbanization stance taken by many developing country policymakers who still try to impede or slow urban growth rather than prepare ahead for it.

Mitigation and adaptation are affected by the physical location of the city and by the way in which it spreads. Disorderly spatial expansion of cities is the pattern that currently prevails. As aptly stated in the aforementioned World Bank study:

> *The key issue facing public sector decision-makers—at the local, national and international levels—is not whether or not urban expansion will take place, but rather what is likely to be the scale of urban expansion and what needs to be done now to adequately prepare for it. . . . the message is quite clear—developing country cities should be making serious plans for urban expansion, including planning for where this expansion would be most easily accommodated, how infrastructure to accommodate and serve the projected expansion is to be provided and paid for, and how this can be done with minimum environmental impact* (Angel et al., 2005, pp. 91 and 95).

The social and sustainable use of urban space would, in and of itself, make a significant difference in the welfare of people and in environmental outcomes. Moving in that direction will require foresight to orient the use of urban land within an explicit concern for both social and environmental values.

Moreover, the built environment will have to be re-conceptualized through urban planning in combination with architectural and engineering solutions. This would include, for instance, alternatives to mechanical air conditioning, e.g., through passive ventilation, building design, green roofs, more energy-efficient manufacturing techniques, renewable energy systems, better landfill management to capture GHG emissions and many other technological initiatives (Abriola et al., 2007).

One specific aspect that requires much greater attention by policymakers in developing countries is attending to the land and housing needs of the poor, who constitute the largest social category (40 per cent) in developing country cities and make up an even larger segment of new urban growth. Their needs are rarely considered effectively in urban planning; this omission has severe implications, not only for urban poverty, but also for urban environmental outcomes and for the quality of life of the entire city population.

Disregard for the land and housing needs of the poor affects both ecosystem services and the city's ability to responsibly and effectively plan for sustainable growth. Given little choice, the poor sometimes occupy ecologically fragile areas and watersheds, thereby endangering the city's water supply and other ecosystem services. The lack of access to water, sewage or solid waste management systems in informal settlements pollutes rivers and affects the appearance, air quality and health of the entire city. Deforestation and the occupation of steep slopes, urban floodplains and wetlands increase the probability of flood damage and landslides.

The lack of attention to the land and housing needs of the poor ultimately affects the very ability of a city to attract investments, to create jobs and to generate a better financial base for implementing improvements in the city. In short, attending to the land and housing needs of the urban poor not only has a direct impact on the reduction of poverty but also affects the city's economic viability and thus its ability to implement climate-friendly policies.

The Relevance of Demographic Composition

Recent research has examined how changes and differences in population composition affect GHG emissions (see, for instance, Dalton et al., 2005). Jiang and Hardee (2009) recently provided a summary of some of the most important findings of these studies, while criticizing climate models for considering only population size and growth.

The literature summarized by Jiang and Hardee shows that: a) population groups of different demographic composition (developed vs. developing countries, small vs. large households, rural vs. urban areas and young vs. elderly) have significantly different consumption and emission behaviours; and b) the proportion of population groups with significantly different consumption and emission behaviours changes importantly over time. Such findings argue for a more disaggregated approach to demographic factors in order to measure the extent of their impacts on greenhouse gas emissions and climate change (pp. 1-5). In brief, the authors suggest that considering only population size as the demographic variable in climate models (as in the IPCC report) leads to an underestimation of the real contribution of 'population' to climate change.

However, existing studies on the effect of household size are largely drawn from developed country experiences. Moreover, smaller households can be seen to be as much a part of 'consumption' as they are of 'population'. They represent a choice in lifestyles and levels of comfort that lead to higher consumption. Thus, what this type of analysis actually does is explain why the responsibility of developed country populations is so much greater in GCC; not only do they normally consume more on a per capita basis, but they also have household arrangements that are conducive to even higher consumption.

The impact of ageing is also shown by Jiang and Hardee to be important, but it is less consistent over time since it is affected by such things as alterations in the composition of the labour force, as well by technological changes and variations in household composition. By contrast, the trend towards shrinking household size is associated with clear increases in consumption per capita, as is a rising proportion of the population residing in urban areas.[7]

This trend is particularly noticeable in developed countries. For instance, it has been observed that the population in the European Economic Area increased by 5 per cent between 1980 and 1995, while the number of households increased by 19 per cent (EEA, 2001). This means that average household size has decreased and emissions have increased, since small households consume more, on a per capita basis, than large ones because of greater residential land use, larger dwellings, greater consumption of appliances and automobiles and thus of energy.

Such changes will be even more meaningful in developing countries, where the bulk of world population and population growth is increasingly concentrated. Analysing the impacts of household change on consumption in different sectors of developing countries would thus appear to be a useful and largely untouched area for future research.

A review of data on ongoing changes in household composition in Brazil provides a glimpse of what may be in store in important segments of the developing world. The country has experienced a remarkable fertility decline, from a Total Fertility Rate of 6 in the mid-1960s to well-below replacement level in the mid-2000s. In addition to rapid population ageing, Brazil is also experiencing important changes in household composition. According to its annual household surveys, Brazil had a total of 39.8 million occupied households in 1996 and 54.6 million in 2006. Thus, while the population grew at an annual rate of 1.41 per cent during this period, the number of households grew at 3.21 per cent. In both the 1996 and 2006 surveys, the most common household arrangement was that of a couple with children, but the number of these decreased from 59.7 per cent in 1996 to 51.6 per cent in 2006 (Barros, 2009, p. 35-36).

The number of households in which both partners worked outside the home also increased significantly in the interim, from 29.7 per cent in 1996 to 41.1 per cent in 2006. A relatively new type of family arrangement, dubbed 'the DINK family' (Double Income, No Kids) in the United States, is also showing rapid growth in Brazil. The number of such households increased from 1.1 million in 1996 to 2.1 million in 2006. Compared to other households, DINKs are considerably younger, with 68 per cent of them headed by a person between the ages of 20 and 39. By comparison, the corresponding proportion for households in that age group having one, two or three children is 90 per cent, 40 per cent and 23 per cent, respectively. Some of the DINK couples may eventually have children, but the 90 per cent increase in the number of such young couples between 1996-2006—at a time when the Brazilian population was going through an ageing process—would suggest that a large proportion of these couples have indeed chosen to be child-free, rather than temporarily childless (Barros, 2009, pp. 35-36).

DINKs have a much higher income; on a per capita basis, it is at least 70 per cent higher than any other group. They are clearly at the apex of the country's income distribution (Alves and Barros, 2009). For our purposes, it is particularly interesting to note that the consumer profile of DINKs differs considerably from those of other families. In general, DINKS place more value on self-satisfaction and the realization of their current consumer and leisure appetites than in preparing the way for future generations (Barros, 2009, p. 14).

The Brazilian DINKs also have higher education levels and more promising careers. Their housing conditions are superior to those of all other groups, in terms of access to water and sanitation and in terms of the number of rooms, as well as the number of bathrooms per person. They also have greater access to goods and services, including appliances, cell phones, computers and access to the internet. No data are available on ownership of automobiles, but the breakdown of expenses among different household arrangements indicates that DINKs spend a greater proportion of their income on leisure and transport than other groups (Barros, 2009, pp. 42-47); such a distribution would seem to be compatible with higher automobile ownership.

In brief, these data would appear to indicate that the tendency to smaller households is already occurring in some of the large developing countries that have achieved very low fertility. Indeed, the same trends have also been observed in other countries in Latin America (Rosero-Bixby, 2008) and in China (about.com, n.d.). The data also seem to show that the smaller household arrangements that spring up after a rapid fertility decline in developing countries are associated with higher consumption, and thus higher emissions, as has been observed in developed countries. The one positive environmental perspective that was noted in the Brazilian case was the fact that a much greater proportion of DINKs tends to live in apartments rather than individual houses (Barros, 2009, p. 45). In principle at least, this pattern is compatible with reduced land use and energy efficiency in edifices, materials and in such energy critical areas as cooling and heating systems—*provided that a conscious planning effort is made in that direction.*

Changing population compositions and policy options

What kinds of population policies might be envisaged in relation to the effects of ageing and changing household composition? The demographic options with respect to ageing are as limited as they have been with respect to mortality: Any action that would affect increased life expectancy in a negative way is as objectionable as suggesting that Malthusian controls will keep population down to manageable levels. Relevant policies here relate to health care improvements and making city infrastructure and services more friendly to an ageing population. Generally, urban areas offer a more favourable environment for actions that can contribute to a healthy and enjoyable ageing. Population concentration, with its advantages of scale and proximity, helps increase access to social services and to new technologies that can have significant implications for their well-being. More than for any other group, urban planning and architecture will have to devise building arrangements that attend to the special needs of the ageing while also intensifying energy efficiency in buildings, transportation and other services.

As concerns household composition, the policies involved would seem to relate to the economic rather than the demographic domain. Paradoxically, smaller households result from fertility decline: Fertility reduction policies are obviously not the answer here since smaller households consume more. It would also be politically and socially inapt to suggest that people should have more children, or that they should live in multi-person households. In this sense, smaller households can more properly be viewed as part of the consumption cluster of driving factors, rather than of the demographic cluster. The same disaggregation that has been advocated when breaking down the influence of demographic factors on GHG emissions would also seem to be necessary when discussing where and how fertility reduction would affect global emissions.

Improving the relationship between smaller households and emissions would entail economic measures, as well as urban planning and architectural innovations. Economic incentives, such as energy taxes, would help limit the environmental consequences of smaller and more consumptive households living in larger buildings, as well as promote the production of energy efficient appliances and products. Innovative planning of urban spaces, allied with engineering advances and construction blueprints that benefit energy efficiency, will have to be developed. Moreover, one might contemplate increased environmental awareness raising and information on the environmental impacts of products. Be that as it may, the point is that, just as there are no acceptable demographic policies to counteract the increasing ageing of populations, it seems that little can be done—from a demographic standpoint—with relation to reduced household sizes except to prepare for new housing arrangements.

Conclusions

The scale and breadth of the well-publicized GCC threats demand positive and interventionist measures capable of turning things around quickly. Intervening in population growth processes appears to be one such initiative. There are already too many of us exploiting our planet, and the prospect of adding on a few billion more is indeed alarming; even small differences in fertility have huge impacts in the long run. Energetic family planning campaigns thus seem to be a good way out for the world, as well as for those women and families burdened with undesired fertility.

Unfortunately, this apparently simple solution has limitations for climate change. Family planning does not have retroactive effects, and the world will continue to have a massive environmental problem even without a single additional birth. The demographic effect of family planning is retarded by inertial factors that extend large population growth for decades beyond the initial fertility decline. Family planning thus does not produce immediate results. It requires prior social development to provide the motivation to use contraception effectively, but this same development also stimulates consumption. Rapid declines of high fertility levels will thus have little impact on GCC in the short run. Even more problematic is the fact that economic growth in large and populous developing countries—whether or not they have already attained low fertility—will ultimately be totally incompatible with the scale of current mitigation efforts under present standards.

In short, if the current resurgence of concern about population growth generates support for the basic right to good reproductive health care for all women, especially those who are unable to achieve their desired family size, then it constitutes a most positive step for women's empowerment, for social human welfare and for longer-term environmental outcomes. However, not even the most intense population control efforts will relieve humankind of the need to drastically redefine development, as well as to forge the pathways that will achieve new development models.

Insufficient attention has been paid to other demographic dynamics and their potential contribution to mitigation. Urban growth processes are currently at a critical stage, given the sheer numbers of people involved and the importance of cities in future global economic, social, demographic and environmental scenarios. Long treated as prime offenders in environmental processes, cities could actually play a key role in both mitigation and adaptation efforts. Countries in Asia and Africa that are undergoing rapid urban growth have an opportunity to make this process work for their own welfare as well as for global environmental well-being. Taking advantage of this opportunity will require radical changes in approaches and the adoption of effective and participatory strategies to urban planning aimed at improving energy efficiency, reducing emissions and providing adequate housing and living conditions for the poor.

Recent research demonstrates the need to discriminate between the impacts of different population groups when drawing up future scenarios. Advances made in the field of population composition, however, are still skimming the tip of the iceberg, and further research is needed in order to understand how the impacts of ageing and different household structures will vary in countries at different levels of development and that have different patterns of social organization. Population policies capable of adjusting to this changing and differentiated context have yet to be clearly defined.

Ultimately, the painful truth that humankind is loathe to face is that consumption aspirations and practices will have to be seriously curtailed in order to reduce the threats of GCC. Stabilizing population growth, putting urbanization to work for mitigation, designing more energy-efficient homes to accommodate new demographic compositions—all this is necessary and helpful, but insufficient. By many accounts, industrialized countries have already outstripped our planet's capacity to withstand 'development' as we know it. Yet, developing countries are desperately trying to emulate the lifestyles and consumption practices of industrialized societies. Although, at the aggregate level, they still have a long way to go, they are already starting to make their own massive impact on GCC. Solving this conundrum will require redefining not only 'development' but also the strongly material content of modern-day 'happiness'. Demystifying the 'saviour' ethos of important but partial solutions, such as those of the demographic domain, is a necessary small step in refocusing the agenda and convincing world society to adopt the inevitable and crucially needed cultural changes.

Notes

1 An earlier version of some of the arguments made here appeared in a previous paper which broached both mitigation and adaptation (see: Martine and Guzman, 2009).

2 Unless otherwise noted, all data on population growth, fertility trends and population composition in this chapter are drawn from United Nations, 2009. Similarly, data on urbanization and urban growth are taken from United Nations, 2008b.

3 Even in the case of China, the impact of birth control measures is questionable. Amartya Sen, for instance, wrote: "What is also not clear is exactly how **much** extra reduction in birth rate China has, in fact, been able to achieve through these coercive methods. We have to bear in mind that China has had many social and economic attainments that are favourable to fertility reduction, including expansion of education in general and female education in particular, augmentation of health care, enhancement of employment opportunities for women, and recently, rapid economic development. . . . While China gets too much credit for its authoritarian measures, it gets far too little credit for other supportive policies it has followed that have helped to cut down the birth rate" (Sen, 1994, p. 22).

4 The following discussion of land use is based in part on Martine, 2008.

5 The denominator in this calculation (130,429,559 km^2) is that used in the GRUMP data set, which omits small islands and other places that have no urban areas. Also, GRUMP's land area is derived from the spatial boundary data, not the official estimates, which in some places may be outdated.

6 This estimate is based on the study by Angel et al. (2005) which assumed an average density of 8,000 per km2 in developing countries and 3,000 per km^2 in industrialized countries.

7 Jiang and Hardee (2009) also illustrate how the understanding of vulnerability and approaches to adaptation could be strengthened with greater attention to demographic factors and changes. Here they emphasize the fact that rapid population growth is likely to occur among population groups—poor, urban and coastal—that are already highly vulnerable to climate-change impacts and in poor countries that cannot cope with their current population sizes.

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2

Does Population Matter for Climate Change?

Hania Zlotnik[1]

Introduction

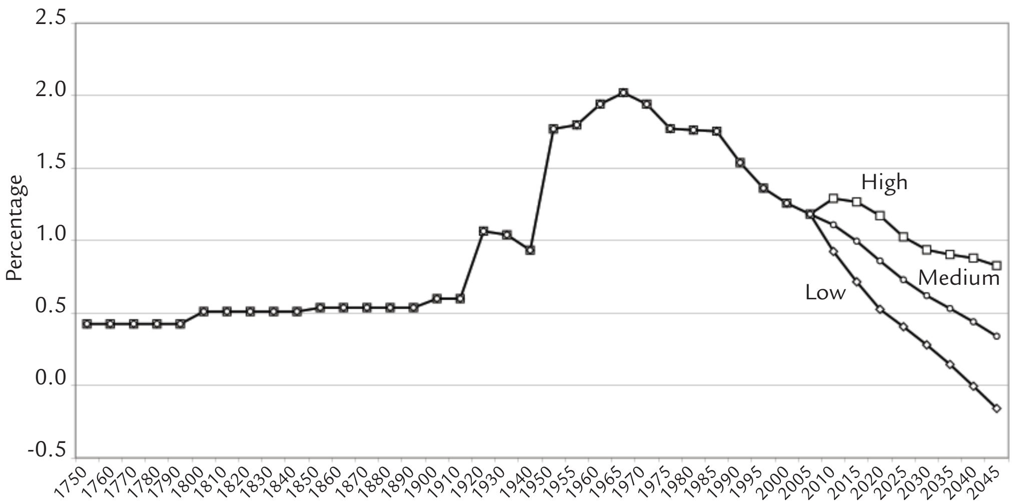
The interrelationships between population and climate change are far from straightforward. Although, at a basic level, the human population and its activities produce the greenhouse gases that are responsible for climate change, establishing the extent to which population growth, changes in the spatial distribution of populations or changes in age or household composition have significant effects on greenhouse-gas emissions net of other factors is difficult, given the association currently observed between standards of living and population growth, with the populations of richer countries generally growing slowly if at all and those of lower-income countries still growing rapidly.

This chapter reviews global population trends and future prospects that must be borne in mind in assessing their implications for environmental sustainability, in general, and climate change, in particular. It then considers to what extent population growth per se has been seen as having an impact on climate change and reviews the long history of the inclusion of population factors and, especially, population growth in the intergovernmental consideration of environmental sustainability in United Nations processes. This review indicates that the disregard of population factors in the current negotiations on climate change is an anomaly. However, as the last section argues, there are a number of reasons for that anomaly, which are likely to keep population factors largely absent from the current climate change debate. Nevertheless, the future growth of world population is too relevant for the sustainability of development and as a factor in the mitigation of climate change for the international community to continue to ignore it. It is essential to take into account the lessons learned from four decades of population policy and active government engagement in enabling people to choose freely and responsibly the number and spacing of their children and providing them with access to the information and means to do so. A serious effort is therefore needed to make the commitments entered into at the International Conference on Population and Development (IPCD), held Cairo in 1994, a reality.

Population Growth: Past and Future

Over the past 200 years, world population has increased from 1 billion to nearly 7 billion. This unprecedented increase resulted mainly from the acceleration of the population growth rate after 1920. As Figure 2.1 shows, the rate of growth hovered around 0.5 per cent per year during the 19th and early 20th centuries and then doubled to about 1 per cent per year during 1920-1940. During the 1940s, the disastrous effects of the Second World War caused the population growth rate to decline to 0.9 per cent annually, but it increased in the 1950s to an annual average of 1.8 per cent and peaked in the late 1960s at 2 per cent per year, a level that, if sustained, would have led to a doubling of the population in just 30 years.

Figure 2.1. Average Annual Rate of Change of World Population, 1760-2050



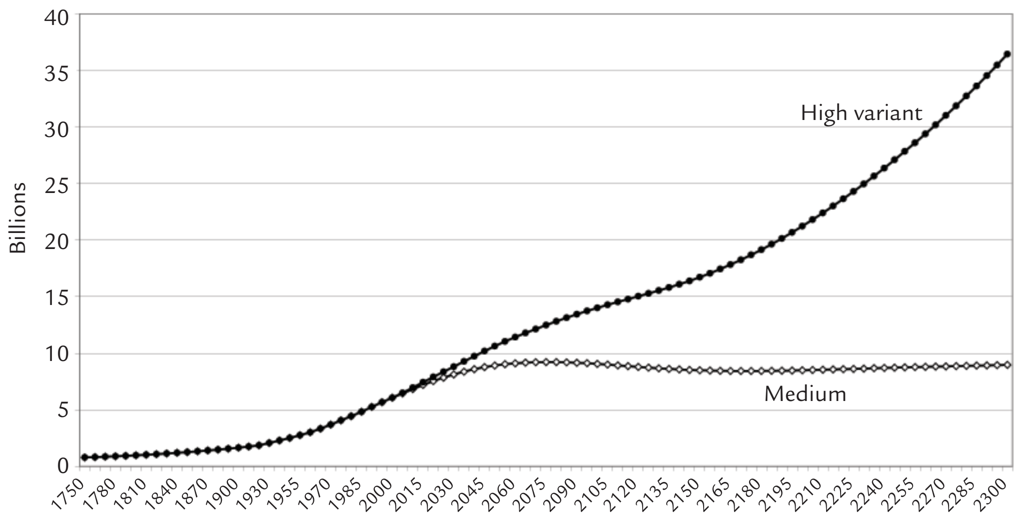
Source: United Nations, 2009c.

In the event, the actual doubling time of the world's population changed from 123 years (from 1 billion in 1804 to 2 billion in 1927) to 47 years (from 2 billion in 1927 to 4 billion in 1974). Because of the rapid reduction of fertility that many developing countries experienced after 1970, the population growth rate has since declined, leading to a slightly longer doubling time in the future: 51 years, from 4 billion in 1974 to the 8 billion expected in 2025. Nevertheless, today's population growth rate is still more than double that prevailing during the 19th century (1.2 per cent vs. 0.5 per cent) and, without further reductions in fertility, world population could surpass 20 billion by the close of the 21st century.

To explore the implications of different fertility paths on future population growth, in 2002, the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat prepared long-range population projections based on different scenarios of future fertility. Those scenarios show that it would be possible to reach a nearly unchanging world population by the end of the 21st century, provided the populations of all countries maintained below-replacement fertility levels for 100 years (at 1.85 children per woman) before returning to replacement level. That scenario, described as 'medium', produces a world population of 9.1 billion in 2100 and just under 9 billion in 2300 (United Nations, 2004).

Although the medium scenario suggests that attaining population stabilization is within reach, the high scenario indicates that small deviations from the fertility path projected in the medium scenario can result in major differences in world population size (Figure 2.2). Thus, by assuming that fertility levels in the high scenario are 0.5 of a child above those projected in the medium scenario until 2050 and between 0.25 and 0.30 of a child higher between 2050 and 2300, future world population will keep on growing, reaching 14 billion in 2100 and 36 billion by 2300 (United Nations, 2004).

Figure 2.2. World Population According to Two Different Scenarios, 1950-2300

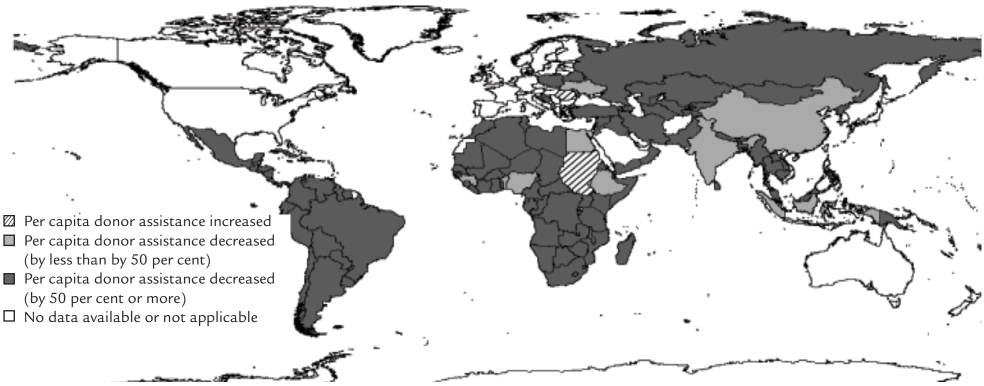


Source: United Nations, 2009c.

Rapid Population Growth in Relation to Climate Change

Today, 47 per cent of the world's population lives in countries where total fertility is already below replacement level, and just 9 per cent lives in countries where fertility levels are still 5 children per woman or higher (United Nations, 2009d). This situation has led most people to believe that population growth is no longer a problem to be reckoned with, and, because most high-income countries today have populations whose fertility has been below replacement level for two or three decades, population decline and rapid population ageing are their immediate concerns. Consequently, donor governments, in particular, and the international community, in general, are focusing less attention on the rapid population

Figure 2.3 Percentage Change in Donor Assistance for Family Planning Programmes per Woman Aged 15-49, 1996 to 2006



Source: United Nations, 2009c.

growth that still characterizes a significant number of developing countries, especially those with the lowest levels of per capita income. Data on donor funding for family planning indicates that in almost all developing countries such funding, expressed per woman of reproductive age, has declined between 1996 and 2006, often by at least 50 per cent (Figure 2.3).

At present, low rates of natural increase (the excess of births over deaths) characterize most high-income countries, whereas low-income countries have both high rates of natural increase and generally high rates of population growth. This negative association between the speed of population growth and per capita income contrasts with the strong positive association that exists between income levels and the production of the greenhouse gases that cause climate change. Thus, as is well known, the countries that produce the lion's share of greenhouse gases are those with high or rapidly increasing per capita incomes and whose populations are generally growing slowly, if at all. In contrast, countries in which the population is still growing fast tend to have low per capita incomes, and their per capita emissions of greenhouse gases are also low. Furthermore, the evidence suggests that rapid population growth in low-income countries can, by itself, be a drag on economic growth (United Nations, 2009c), thus further contributing to keeping their per capita greenhouse gas emissions low. Consequently, the linkages between population growth and climate change are far from straightforward. In order to consider the potential impact of population growth on climate change, account must be taken of the interrelationships between population growth, economic development, energy use and deforestation, as well as on the impact of all these processes on global warming.

Complex models that take into account the effects not only of population growth but also of changes in the age structure of populations and their distribution between urban and rural areas on economic productivity, economic growth and energy use indicate that population change, driven by changing fertility, can have a sizeable impact on the production of greenhouse gases. Full results of such models have not yet been published, but the preliminary results of scenarios to 2100 show that maintaining a lower population growth rate, particularly in the rapidly growing economies of the developing world and in high-income countries, would by itself make a sizeable contribution to the reduction in greenhouse gas emissions considered necessary to prevent dangerous global warming (O'Neill, forthcoming).

It is worth reviewing the assumptions regarding future population growth underlying the scenarios of future greenhouse gas emissions developed by the Intergovernmental Panel on Climate Change (IPCC, 2000). For the A1 and B1 families of scenarios, the IPCC uses a population projection that combines low fertility with low mortality and migration. World population in that projection peaks at 8.7 billion in 2050 and declines to 7.1 billion in 2100. The A2 family of scenarios is based on a high population projection where world population reaches 15 billion in 2100. The B2 family of scenarios uses a medium population projection in which world population reaches 9.4 billion in 2050 and rises to 10.4 billion in 2100. Because each family of scenarios varies with respect to other assumptions about future economic development, comparing their outcomes does not allow an assessment of the effect that population growth per se would have on greenhouse gas emissions. Furthermore, given that population and economic growth are interrelated, it would be unrealistic to model a future in which only population growth varies from one scenario to the next. In fact, in setting assumptions about future economic growth, the IPCC acknowledges its interrelationships with population trends and therefore assigns the highest economic growth to the family of scenarios with the slowest population growth (A1 with a growth rate of 2.9 per cent per year and B1 with 2.5 per cent per year).

The other two families of scenarios are assigned a medium level of economic growth (B2 with 2.2 per cent annually on average) or a low one (A2 with 1.3 per cent annually on average). The fourth assessment report of the IPCC presents the results of the different scenarios with respect to their impact on climate change (IPCC, 2007). Those results are sobering, because they indicate that the impact on climate change is highest in the A2 scenario despite the low economic growth it embodies. Both the rapid population growth it incorporates and its assumption of slow technological change contribute to that result. Only one family of scenarios, denoted A1F1, which incorporates low population growth combined with continued high use of fossil fuels, produces worse effects on the climate than A2.

The stark reality is that a reduction of greenhouse gas emissions requires lower overall consumption of energy derived from fossil fuels. Hence, the more people there are on Earth, the more the per capita use of fossil fuels needs to decrease to attain safe emissions levels. Existing disparities in energy use stemming from sharp differences in per capita incomes add complexity to the argument, but do not invalidate the fact that current levels of population growth cannot continue over the long run without endangering the sustainability of the planet, particularly if standards of living are to be improved for a growing population.

Population and the Environment in the United Nations: A Historical Perspective[2]

Consideration of the interrelationship between population trends and the environment began with the founding of the United Nations. Those interrelationhips were the focus of the first session of the United Nations Population Commission (now the Commission on Population and Development) held in 1947 (United Nations, 2001). At that time, the discussion was mostly framed in terms of whether the natural resources needed to ensure that the large population growth expected over the next few decades would be compatible with economic development. The need to ensure adequate access to land for a growing rural population in order to maintain or increase agricultural production was also a prominent focus of discussion. In the 1950s, data on demographic and socio-economic trends in developing countries were scarce. Consequently, the first studies on the relationship between population and the environment related mostly to the experience of developed countries and tended to focus on how socio-economic development shaped demographic trends by improving health and contributing to changing the norms on the number of children desired.

In the 1960s, awareness that global population growth was reaching very high and unprecedented levels raised concerns about overall environmental sustainability. In response, the General Assembly decided to convene a United Nations Conference on the Human Environment (resolution 2398 [XXIII] of 3 December 1968), noting that "rapidly increasing population and accelerating urbanization" were accentuating the "continuing and accelerating impairment of the quality of the human environment". A subsequent report of the Secretary-General (United Nations, 1969) cited the explosive growth of human populations as "first among the portents of a crisis of worldwide scope concerning the relation between man and his environment" (United Nations, 2001).

Held in Stockholm in 1972, the conference adopted a Declaration (United Nations, 1973, ch. I) and an Action Plan for the Human Environment (ch. II). Those documents guided the activities of the United Nations system on environmental issues during the 1970s and 1980s. Although population growth was recognized as a relevant factor in relation to the environment, and paragraph 5 of the Declaration stated that "the natural growth of population continuously presents problems for the preservation of the environment, and adequate policies and measures should be adopted, as appropriate, to face these problems", it was left to the United Nations World Population Conference held in Bucharest in 1974 to consider the issue of population and its consequences for the environment.

Late in 1973, an expert Symposium on Population, Resources and the Environment was convened in preparation for the World Population Conference. The state of knowledge at the time did not yield strong conclusions about the interrelationships between population size and growth, on the one hand, and the environment on the other, mainly because, as experts recognized, population was only one of the factors—and not necessarily the most important—causing resource and environmental problems. At the conference itself, the debate reflected profound divergences in the perception of the population-environment interactions among Member States, differences that continue to this day. As a result, the World Plan of Action adopted by the World Population Conference gave only cursory treatment to the interrelations between population and the environment.

In 1984, a second intergovernmental conference on population, the International Conference on Population, was held in Mexico City. The conference adopted recommendations for the further implementation of the World Population Plan of Action (United Nations 1984, ch. I, sect. B [III and IV]) which acknowledged the importance of environmental issues by calling for national development policies and international development strategies based on an integrated approach that would take into account the relationships among population, resources, environment and development (recommendation 1). Furthermore, using language that would become the cornerstone of the development paradigm of the 1990s, the recommendations stipulated that the formulation of national population goals and policies should take into account the need for long-term environmentally sustainable economic development (sect. B, para. 8). More specifically, the conference urged the governments of "countries in which there are imbalances between trends in population growth and resources and environmental requirements" to adopt and implement, "in the context of overall development policies, . . specific policies, including population policies, that will contribute to redressing such imbalances . . ." (United Nations, 1984, ch. I, sect. B [III, recommendation 4]).

The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, was a milestone in the evolution of an international consensus on the interrelations between population and the environment, based on the concept of 'sustainable development', defined by the report of the World Commission on Environment and Development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (para. 1, United Nations, 1987, annex). Even more explicitly, the World Commission declared in its report that poverty, environmental degradation and population growth were inextricably related and that none of those problems could be successfully addressed in isolation. The Commission's report noted that, in several regions of the world, rapid population growth had exceeded the available natural resources and was jeopardizing development possibilities. Moreover, the fact that curbs on population growth were necessary made it imperative to integrate population programmes into mainstream development efforts. Although members of the World Commission remained divided on both the significance of population growth as a cause of environmental degradation and on concrete policy prescriptions, the prominence given to the issue raised its visibility on the international agenda (United Nations, 2001).

Influenced by the findings of the commission, the Rio Declaration on Environment and Development identified population policies as an integral element of sustainable development, and principle 8 of the Rio Declaration stated that "to achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies" (United Nations, 1993, resolution 1, annex I, principle 8). Furthermore, chapter 5 of Agenda 21 (United Nations, 1993, resolution 1, annex II) addressed demographic dynamics and sustainability and noted that "the growth of world population and production combined with unsustainable consumption patterns places increasingly severe stress on the life-supporting capacities of our planet" (para. 5.3).

These issues were revisited at the International Conference on Population and Development (ICPD), held in Cairo in 1994. The central theme of the conference was to forge a balance among population, sustained economic growth and sustainable development. The Programme of Action adopted by the conference recognized "that population, poverty, patterns of production and consumption and the environment are so closely interconnected that none of them can be considered in isolation" (United Nations, 1995, ch. I, resolution 1, annex, para. 1.5) and acknowledged that population factors could sometimes be inhibitors of sustainable development: "Demographic factors, combined with poverty and lack of access to resources in some areas, and excessive consumption and wasteful production patterns in others, cause or exacerbate problems of environmental degradation and resource depletion and thus inhibit sustainable development" (para 3.25). Crucially, the Programme of Action noted that "slower population growth has in many countries bought more time to adjust to future population increases. This has increased those countries' ability to attack poverty, protect and repair the environment, and build the base for future sustainable development. Even the difference of a single decade in the transition to stabilization levels of fertility can have a considerable positive impact on quality of life" (para 3.14).

In June 1997, when the General Assembly conducted the first five-year review of the implementation of Agenda 21, it concluded that, whereas many of the overall trends that impacted on sustainable development had become worse since 1992, population growth rates had continued to decline at the global level, and, if such trends continued, the stabilization of the world population could be reached during the 21st century. The *Programme for the Further Implementation of Agenda 21* adopted in 1997 (General Assembly resolution S-19/2, annex) affirmed that:

> *The impact of the relationship among economic growth, poverty, employment, environment and sustainable development has become a major concern. There is a need to recognize the critical linkages between demographic trends and factors and sustainable development. The current decline in population growth rates must be further promoted through national and international policies that promote economic development, social development, environmental protection, and poverty eradication, particularly the further expansion of basic education, with full and equal access for girls and women, and health care, including reproductive health care, covering both family planning and sexual health, consistent with the report of the International Conference on Population and Development* (United Nations, 1997, para. 30).

In 2000, the General Assembly adopted the United Nations Millennium Declaration (United Nations, 2000), which set a number of key development goals regarding, inter alia, the reduction of poverty and hunger, the attainment of universal basic education, the reduction of child and maternal mortality and the promotion of gender equality. The Millennium Declaration also contained a section focusing on the protection of "our common environment" (sect. IV) but the issues highlighted in it did not include population growth. Nor was population growth mentioned in the outcome documents of the World Summit on Sustainable Development held in Johannesburg in 2002, although the Johannesburg Plan of Implementation adopted by the Summit mentioned the crucial role that agriculture plays in "addressing the needs of a growing population" (United Nations, 2002, para. 40). It also called for the strengthening of health systems in order to "address effectively, for all individuals of appropriate age, the promotion of healthy living, including their reproductive and sexual health, consistent with the commitments and outcomes of recent United Nations conferences and summits" (para. 54[j]).

In regard to the United Nations Climate Change Conference that will be held in Copenhagen in December 2009, the draft of the outcome document that is still under negotiation makes no mention of population dynamics or population growth.

Why Has Population Disappeared from the Environmental Debate?

A number of reasons can be given for the disappearance of population growth as an issue to be considered in finding ways to mitigate climate change. The first reason was acknowledged in 1997 when the first five-year review of the implementation of Agenda 21 concluded that the declining trend in the global rate of population growth was a success (United Nations, 1997). Since then, the continuing decline in the growth rate has not been conducive to eliciting the sense of urgency that was common among policymakers in the 1970s and 1980s, despite the fact that, because of population momentum, increasing numbers of people will have to be accommodated on the planet no matter how rapidly that rate falls.

The second reason relates to the fact that two distinct trends are causing the reduction of the global growth rate: reductions in fertility, on the one hand, and increases in mortality in the countries most affected by the HIV/AIDS epidemic on the other. As a result of the 1994 ICPD, policies and programmes related to fertility trends, as well as efforts to control the HIV/AIDS pandemic, have been subsumed under the class of actions aimed at improving reproductive and sexual health. Within that group, programmes for the prevention and treatment of HIV/AIDS, which hardly existed in the early 1990s, have expanded markedly, absorbing an ever increasing share of the available funding (United Nations, 2009a). It is partly for this reason that donor financing for family planning has declined on a per capita basis and that the attention of the international community has shifted toward major health issues, including both the control of the HIV/AIDS pandemic and the reduction of maternal and child mortality.

A third reason involves the key feature of the ICPD Programme of Action: the recognition by the international community of the existence of reproductive rights. Within the United Nations, the first mention of a right related to human reproduction dates from 1968, when the International Conference on Human Rights adopted the Proclamation of Teheran in which the international community recognized that "parents have the basic human right to determine freely and responsibly the number and the spacing of their children" (United Nations, 1968, para. 16). The characterization of this basic human right was developed further in the Principles and Objectives of the World Population Plan of Action adopted by the World Population Conference in 1974, which states in paragraph 14(j) that "[a]ll couples and individuals have the basic right to decide freely and responsibly the number and spacing of their children and to have the information, education and means to do so; the responsibility of couples and individuals in the exercise of this right takes into account the needs of their living and future children, and their responsibilities towards the community" (United Nations, 1975).

In addition, the World Population Plan of Action, which was the first United Nations document to provide guidance to governments on how to develop population policies, noted explicitly that those policies should conform to human rights, as stated in para. 17: "Countries which consider that their present or expected rates of population growth hamper their goals of promoting human welfare are invited, if they have not yet done so, to consider adopting population policies, within the framework of socio-economic development, which are consistent with basic human rights and national goals and values."

Over the next two decades, as increasing numbers of countries formulated and implemented population policies, the recognition that successful policies had at their core a full respect for human rights was strengthened. The result was the characterization of reproductive rights that was adopted in 1994 by the ICPD, the main tenets of which are that:

> *. . . reproductive rights embrace certain human rights that are already recognized in national laws, international human rights documents and other consensus documents. These rights rest on the recognition of the basic right of all couples and individuals to decide freely and responsibly the number, spacing and timing of their children and to have the information and the means to do so, and the right to attain the highest standard of sexual and reproductive health. It also includes the right to make decisions concerning reproduction free of discrimination, coercion and violence, as expressed in human rights documents. In the exercise of this right, they should take into account the needs of their living and future children and their responsibilities toward the community. The promotion of the responsible exercise of these rights for all people should be the fundamental basis for government- and community-supported policies and programmes in the area of reproductive health, including family planning. As part of their commitment, full attention should be given to the promotion of mutually respectful and equitable gender*

> *relations and particularly to meeting the educational and service needs of adolescents to enable them to deal in a positive and responsible way with their sexuality* . . . . (United Nations, 1995, para. 7.3).

The holistic approach to reproductive and sexual health implicit in the above and the explicit mention of the needs of adolescents were major steps forward, but they have contributed to weakening the focus of population policies on family planning. This outcome was not intended by the framers of the ICPD Programme of Action, which contains a full section on family planning. The "basis of action" presented in that section is well worth recalling because it distills the accumulated experience of three decades of family planning programmes:

> *The aim of family-planning programmes must be to enable couples and individuals to decide freely and responsibly the number and spacing of their children and to have the information and means to do so and to ensure informed choices and make available a full range of safe and effective methods. The success of population education and family-planning programmes in a variety of settings demonstrates that informed individuals everywhere can and will act responsibly in the light of their own needs and those of their families and communities. The principle of informed free choice is essential to the long-term success of family-planning programmes. Any form of coercion has no part to play. In every society there are many social and economic incentives and disincentives that affect individual decisions about child-bearing and family size. Over the past century, many Governments have experimented with such schemes, including specific incentives and disincentives, in order to lower or raise fertility. Most such schemes have had only marginal impact on fertility and in some cases have been counterproductive. Governmental goals for family planning should be defined in terms of unmet needs for information and services. Demographic goals, while legitimately the subject of government development strategies, should not be imposed on family-planning providers in the form of targets or quotas for the recruitment of clients* (para. 7.12).

To sum up, the third reason for the increasing invisibility of population issues in the environmental debate is the change of focus from family planning to the holistic approach implicit in reproductive health, coupled with certain legacies of what some people characterize as 'the population control era' in which governments expected family planning programmes to meet explicit demographic goals and used incentives or disincentives to achieve those goals. The sensitivities surrounding these issues make them difficult to address in international negotiations, especially when, as in the case of negotiations on how to prevent climate change, many other challenging issues are yet to be settled. Furthermore, although population trends are likely to shape the future paths of greenhouse gas emissions in significant ways, their effect is still far in the future even if the time to act is now.

If Population Is Relevant for Climate Change, What Next?

So, does population matter for climate change? This chapter has provided several reasons for the answer to be in the affirmative, but, in a manner reminiscent of the first United Nations Conference on the Human Environment, the international community is likely to leave the debate on future population trends and how to shape them to the next international conference on population. In the meantime, there is still much to be done. Indeed, universal access to reproductive health, one of the key goals of the ICPD Programme of Action—echoed by the 2005 World Summit (United Nations, 2005) and now part of the framework of the Millennium Development Goals—is still far from being achieved. Unmet need for family planning is significant in many countries and particularly in the least-developed countries, where 23 per cent of women of reproductive age who are married or in a union have an unmet need for family planning (United Nations, 2009b). In the least-developed countries, only 24 per cent of those women use a modern method of contraception, whereas 60 per cent do so in the rest of the developing world. There is also a need to improve access to a full range of family planning methods in developing countries, since, in many, contraceptive use is heavily clustered in just one or two methods.

Experience has shown that the best decisions about family planning are those that people make for themselves, based on accurate information and a range of contraceptive options. People who make informed choices are better able to use family planning safely and effectively (Upadhyay, 2001). To enable people to make informed choices, governments can ensure that people have access to a full array of methods and eliminate unnecessary medical barriers to access. Governments can also develop communication programmes to convey the message that people have a right to information about their health and can make family planning decisions for themselves, based on their own needs and desires. Communication programmes should also encourage people to visit family planning providers and prompt them to ask questions and express any concerns they may have. Managers of family planning programmes should make informed choice the norm in service delivery and ensure that service providers are trained to provide information without interfering in the ability of clients to make decisions. Governments can take measures to ensure that a variety of methods are available through as many service delivery outlets as possible. Donors can support free choice by ensuring that family planning programmes have adequate supplies of a wide array of contraceptive methods. All these actions are consistent with the guidance provided by the ICPD Programme of Action. There is ample experience to show that, with government commitment, the strategies and tools to ensure that people can exercise their reproductive rights effectively can produce the population trends that will, over the medium and long term, contribute to ensuring the sustainability of life on the planet. Given the enormous challenges that achieving sustainability poses, there is no time to lose.

Notes

1 The views and opinions expressed in this paper are those of the author and do not necessarily reflect those of the United Nations.

2 This section draws extensively on Chapter I of United Nations, 2001.

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3

The Implications of Population Growth and Urbanization for Climate Change

David Satterthwaite

Introduction

It has long been common for population growth to be blamed for a range of environmental problems, but for the usually far more damaging contributions of high consumption to be downplayed (Hartmann, 1998; Satterthwaite, 2003). This misconception is now being applied to climate change. Cities, or urbanization in general, are frequently blamed for human-induced greenhouse gas (GHG) emissions and hence for climate change. The realities on both fronts are more complex. This chapter considers some of these complexities and tries to find more precise ways to allocate responsibility.[1]

Achieving More Precision in Allocating Responsibility for Climate Change

Most of the growth in the world's population is taking place in urban areas in low- and middle-income nations, and this is likely to continue (United Nations, 2008). Thus, a concern for how the growth in the world's population influences GHG emissions is largely a concern for how the growth in the urban population in low- and middle-income countries influences GHG emissions. An assessment of the contribution to climate change of urban centres or urbanization (growth in the proportion of a national population living in urban areas) or the growth in urban populations can be done either from the perspective of 'where GHGs are produced' (by assessing what proportion of GHGs emitted by human activities comes from within the boundaries of urban centres) or from the consumption perspective (assessing all the GHGs emitted as a result of the consumption and waste generation of urban populations no matter where they originated). Table 3.1 lists the most likely sources of growing GHG emissions for any city or any nation's urban population from these two perspectives.

Table 3.1: Possible Drivers of Growing Greenhouse Gas Emissions of the Urban Population in a City or in a Nation

From the perspective of where the GHGs are produced:

Sector	What drives growing greenhouse gas emissions in urban areas?	What can moderate, stop or reduce this growth?
Energy supply	Largely from fossil fuel power stations, resulting in a growth in electricity provision from high GHG-emitting sources; while many large fossil fuel power stations are located outside urban areas, the GHG emissions from the electricity used are usually allocated to these urban areas (see below).	A shift to less GHG-emitting power generation and distribution; incorporation of electricity-saving devices; an increase in the proportion of electricity generated from renewable energy sources and its integration into the grid.
Industry	Growing levels of production; growing energy intensity in what is produced; increasing importance of industries producing goods, the fabrication of which entails large GHG emissions, e.g., motor vehicles.	A shift away from heavy industries and from industry in general to the service sector; increasing energy efficiency within enterprises; capture of particular GHGs from waste streams.
Forestry and agriculture	Many urban centres have considerable agricultural output and/or forested areas, mostly because of extended boundaries that encompass rural areas; from the production perspective, GHGs generated by deforestation and agriculture are assigned to rural areas.	
Transport	Growing use of private automobiles; increases in average fuel consumption of private automobiles; increased air travel (although this may not be allocated to urban areas).	Increasing the number of trips made on foot, by bicycle, on public transport; a decrease in the use of private automobiles and/or a decrease in their average fuel consumption (including the use of automobiles using alternative fuels); ensuring that urban expansion avoids high levels of private automobile dependence.
Residential/ commercial buildings	Growth in the use of fossil fuels and/or growth in electricity use from fossil fuels for space heating and/or cooling, lighting and domestic appliances.	Cutting fossil fuel/electricity use, thus cutting GHG emissions from space heating (usually the largest user of fossil fuels in temperate climates) and lighting; much of this is relatively easy and has rapid paybacks.
Waste and wastewater	Growing volumes of solid and liquid wastes and of more energy-intensive waste.	Reducing volumes of wastes; waste management that captures GHGs.

From a consumption perspective:

Sector	What drives growing greenhouse gas emissions in urban areas?	What can moderate, stop or reduce this growth?
Energy supply	GHGs from energy supply/electricity now assigned to consumers, so GHG growth is driven by increasing energy use; consumers are also allocated the GHGs from the energy used to make and deliver the goods and services they consume.	As with the production perspective, but also a greater focus on less consumption among high consumption households; a shift to less GHG-intensive consumption.
Industry	GHGs from industries and from the production of the materials they use no longer allocated to the enterprises that produce them, but rather to the final consumers of the products; so again, GHG growth driven by increased consumption.	As in the production perspective, but with an extra concern to reduce the GHGs embedded in goods consumed by residents and to discourage consumption with high GHG emissions implications.
Forestry and agriculture	GHGs from these no longer allocated to rural areas (where they are produced), but rather to the consumers of their products (many or most in urban areas); note that most commercial agriculture has become more energy intensive; also, the high GHG implications for preferred diets among higher-income groups (including imported goods, high meat consumption, etc.).	Encouraging less fossil-fuel-intensive production and supply chains for food and forestry products; addressing the very substantial non-CO_2 GHG emissions from farming (including livestock); forestry and land-use management practices that contribute to reducing global warming.
Transport	As in the production perspective; GHG emissions from fuel use by people travelling outside the urban areas in which they live are allocated to them, including air travel; also concern for GHG emissions arising from investment in transport infrastructure.	As in the production perspective, but with a stronger focus on reducing air travel and a concern for lowering the GHG emissions implications of investments in transport infrastructure.
Residential/ commercial buildings	As in the production perspective, but with the addition of GHG emissions arising from construction and building maintenance (including the materials used to do so).	As in the production perspective, but with an added interest in reducing the CO_2 emissions embedded in building materials, fixtures and fittings.
Waste and wastewater	Large and often growing volumes of solid and liquid wastes which contribute to GHGs; these are allocated to the consumers who generate the waste, not to the waste or waste dump.	As in the production perspective, but with a new concern to reduce waste flows that arise from consumption in the city but contribute to GHGs outside its boundaries.
Public sector and governance	Conventional focus of urban governments on attracting new investment, allowing urban sprawl and heavy investment in roads, with little concern for promoting energy efficiency and low GHG emissions.	Governance that encourages and supports all the above remedies; also, a strong focus on lowering GHG emissions through better management of government-owned buildings and public infrastructure and services, including a concern for reducing GHG emissions generated in constructing infrastructure and in the delivery of services.

It is noticeable that all the drivers of the growing GHG emissions shown in Table 3.1 can occur (and often have taken place) in a national urban population or in a particular city not experiencing population growth. This is particularly the case if the consumption perspective is adopted. For instance, Greater London's population was larger in 1941 than it is today, but the total GHG emissions generated by its population's consumption are likely to have increased many times.

From the production perspective, if energy intensive production is concentrated in cities, their average GHG emissions per person will increase (unless the production is served by electricity not generated from fossil fuels). This can mean that particular cities in low- and middle-income nations with heavy industry or fossil-fuelled power stations can have very high carbon dioxide (CO_2) emissions per person. But in many nations, a considerable proportion of energy intensive production (for instance, mines and mineral processing) or fossil-fuelled electricity generation takes place in rural areas or urban areas too small to be considered cities. Rural districts with such energy-intensive production can have per capita GHG emissions that are much higher than most cities—although most city GHG emissions inventories that use the production perspective[2] use the consumption perspective with regard to electricity (wherein the emissions generated by the electricity used in the city are allocated to the city, not to the location where the electricity was generated). In addition, when comparisons for GHG emissions are made between rural and urban areas, where the high contribution of urban areas is stressed, generally, no consideration is given to emissions from agriculture and land-use changes in rural areas. The Intergovernmental Panel on Climate Change (IPCC) suggests that the latter accounts for around 31 per cent of all human-induced GHG emissions (Metz et al., 2008).

One obvious objection to using the production perspective is that a large proportion of the products of rural-based mines, forests and agriculture, as well as land-use changes, are meant to serve the production or consumption needs in urban areas. Therefore it is misleading to allocate these to rural areas (or rural populations). But the real issue here is the inappropriateness of allocating responsibility for GHG emissions to a nation as a whole (and by implication to that nation's entire population) or to urban areas in general or to particular cities (and by implication to all the urban population or to the populations of particular cities). Human-induced GHG emissions are not caused by 'people' in general, but by specific human activities by specific people or groups of people. It is not 'urban populations' in general that account for high private automobile use or high levels of air travel or high consumption lifestyles, but particular individuals or households (including many that live in rural areas). *In order for any individual or household to contribute to global warming, they have to consume the goods and services that generate GHG emissions.*

The dominant underlying cause of global warming is the consumption of goods and services that draw on resources for their fabrication, distribution (or provision), sale and use (and, for goods, disposal) resulting in the emission of GHGs. Of course, consideration also needs to be given to the (now heavily globalized) production systems that serve this (and that also do so much to encourage high consumption).

A significant proportion of the world's urban (and rural) populations have very low levels of GHG emissions because their use of fossil fuels and of the electricity generated by them—and the fossil-fuel input into the goods or services they consume—is very low, and their consumption patterns contribute little or nothing to the generation of other GHG emissions. In many low-income nations, most rural and urban households do not have electricity, and thus no household appliances that use electricity.[3] For low-income households in rural and urban areas in most of the lowest-income nations, recent Demographic and Health Surveys (DHSs) show that fuel use is still dominated by charcoal, fuelwood or organic wastes (e.g., dung). Where access to these is commercialized, as is likely in most urban centres, total fuel use among low-income populations will be low because fuel is expensive. If urban households are so constrained in their income levels that many family members are severely undernourished and can afford only one meal a day, it is unlikely that their consumption patterns are generating much GHGs. In addition, their fuel use may be largely or completely based on renewable resources, which means no net contribution to GHG emissions.[4]

Drawing on data for cooking fuel use and access to electricity for urban populations from recent DHSs,[5] among the 44 nations for which data were available, 17 had more than half of their urban populations relying primarily on non-fossil fuel for cooking. There were also 11 nations where more than half of urban households did not have access to electricity. But even when low-income households do shift to fossil-fuel-based energy sources—typically kerosene in low-income nations—their consumption levels remain low. Low-income households in Delhi that rely on kerosene typically use 25–30 litres per month (Dhingra et al., 2008), which implies CO_2 emissions per person per year of around 0.15–0.2 tonnes (very small by global standards). Low-income urban households also use transport modes that produce no GHG emissions (walking, bicycling) or low GHG emissions (buses, mini-buses and trains, mostly used to more than full capacity). To give an illustration of how low consumption levels are, in Kibera, Nairobi's largest informal settlement (with around 600,000 inhabitants), a 1998 survey found that only 18 per cent had electricity, only 7 per cent had a bicycle and only 1.5 per cent had a refrigerator; 31 per cent of all households surveyed had no radio, television or refrigerator (APHRC, 2002).

When low-income urban-dwellers do obtain electricity, the few studies available suggest that consumption levels are often very low. For instance, among low-income households in three Indian cities (Kulkarni and Krishnayya, 1994), just 32–33 kilowatt hours per month were used (1/20th to 1/40th of the average per person in most high-income nations). A very considerable number of people (both rural and urban) may have zero or negative GHG emissions per person. Included among these are many low-income urban-dwellers whose livelihoods are based on reclaiming and re-using or recycling waste. The GHG emissions 'saved' from their work equals or exceeds the GHG emissions that their consumption causes. It may also include tens of millions of small farmers able and willing to engage in sustainable agriculture and in maintaining or increasing forests on their land. Thus, perhaps up to one sixth of the world's population has incomes and consumption levels that are so low they are best not included in allocations of responsibility for GHG emissions.

The failure of more than 50 years of development to reduce the number of people living in poverty (which also means failing to reduce the number with very low and inadequate consumption levels)[6] suggests that a very considerable proportion of the world's population will continue to live in extreme poverty and, in effect, contribute very little to future GHG emissions. Of course, how income distribution changes within urban (and rural) populations has very large implications for future GHG emissions. For instance, a household in Mumbai with an income of 150,000 rupees a month (around U$3,125) is likely to contribute far more GHG emissions than a pavement-dweller household.

Thus, the much-used formula of I = P*A*T (impact relating to population, affluence and technology) should be changed to I = C*A*T when applied to global warming impacts, with C being the number of consumers, not the number of people. In addition, it is neither fair nor accurate to suggest that either population growth or urbanization necessarily causes increases in GHGs. This increase depends more on the form and levels of consumption among the growing population or among the population that moves to urban areas (the immediate cause of urbanization). For example, many urban centres in sub-Saharan Africa and low-income nations in Asia (including many with growing populations) are likely to have very low average GHG emissions per person—whether from the production perspective (they have very little or no industry and most of the population has very low fossil-fuel use within households or for transport) or the consumption perspective (with a very low proportion, or no, residents with high consumption lifestyles). This is not recognized, partly because there are no data available on their emissions, but note should be taken of the many nations whose average annual per capita CO_2 emissions are below 0.2 tonnes (i.e., less than 1/200th that of the United States or Canada). In 2005, 13 nations had average CO_2 emissions per person that were less than 0.1 tonnes. In contrast, as discussed in more detail below, there are nations with slow or no population growth and very small increases in urbanization levels where both total GHG emissions and GHG emissions per person have increased rapidly in recent decades. This would be even more the case if there were statistics for GHG emissions from a consumption perspective.

In addition, it is unfair to equate increases in GHG emissions per person among low-income populations (for example, from 0.1 to 0.5 tonnes of CO_2e per person per year[7]) with comparable GHG increases among high-income populations (for instance, from 7.1 to 7.5 tonnes per person per year). The reduction in global emissions needed to avoid dangerous climate change depends on achieving a particular global average for emissions per person—what is sometimes termed the 'fair share' level, generally set at around two tonnes of CO_2e per person. Making provision for increases in GHG emissions for those people below the 'fair share' level so that they can move out of what might be termed 'energy poverty' cannot be considered in the same light as increases in emissions from those already above the 'fair share' level.

If what is stated above is accepted, the discussion of the links between population and the causes of climate change (and, within this, the links between urbanization and the causes of climate change) is altered. Perhaps the most fundamental point is that increases in GHG emissions per person by people living below the global 'fair share' level should be treated differently from increases by people above it. Most of the nations with the most rapid growth in their national (and urban) populations have average GHG emissions per person far below the 'fair share' level.

How Much Does Population Growth Coincide with the Growth in Greenhouse Gas Emissions?

It is worth considering in more depth the extent of the association between population growth and the growth of GHG emissions. As noted, many of the nations with the most rapidly growing national and urban populations have very low levels of CO_2 emissions per person and have experienced slow growth in these emissions, while many of the nations with the slowest growing national and urban populations have the highest levels of GHG emissions per person and have had a rapid growth in CO_2 emissions per person. Between 1980 and 2005, some high-income nations had a slow growth in CO_2 emissions per person because they already had very high per capita emissions. If data were available for the consumption perspective, it is likely that they would show that high-income nations have had a much greater growth in emissions per capita, and many low- and middle-income nations have had much less.

Looking first at the nations with the highest and lowest CO_2 emissions per person, data are available for average CO_2 emissions per person for 185 nations for 1980 and 2005.[8] These can be divided into five sets of 37 nations each. All but ten of the 37 nations with the highest CO_2 emissions per person in 2005 were high-income nations (encompassing North America and much of Europe). Three small population, high-income Middle-East oil producers had the highest emissions (Kuwait, Qatar and the United Arab Emirates) and very high population growth rates (mostly from immigration). But generally, this group of high-emissions nations had very low population growth rates between 1980 and 2005 (more than half had average population growth rates of less than 1 per cent a year for this period). Of the 37 nations with the lowest CO_2 emissions per person, all were low-income nations, and most (29) were in sub-Saharan Africa; 34 had population growth rates of more than 2 per cent a year; and nine had population growth rates of more than 3 per cent a year.

Thus, when considering how CO_2 emissions per person change in relation to population growth, for the period 1980-2005, many of the nations with among the slowest population growth rates had among the fastest growth rates in CO_2 emissions, while many of the nations with among the fastest population growth rates had among the slowest increases in CO_2 emissions. The countries with low population growth and high CO_2 emissions growth are mostly high-income or upper-middle income nations, most are in Europe or Asia, and all had very considerable economic success in the period 1980-2005; the high population growth, low emissions growth countries are mostly low-income nations, most are in sub-Saharan Africa, and many had little economic success during this period. Clearly, any consideration of changes in a nation's CO_2 emissions in the last few decades cannot be separated from a consideration of economic changes that include the extent (or not) of economic growth and the sectors where this growth took place, as well as changes in incomes and how these were distributed within the national population.

For China, the very rapid growth in production (much of it for export) from 1980 to 2005 is an important contributor to its rapid growth in CO_2 emissions. This is also likely to have been the case for South Korea and perhaps for Thailand. For several nations, including Chile, New Zealand, Portugal and South Korea, it is likely that the growth in per capita income and increases in incomes (and in consumption) that benefited a large part of their national populations are important underpinnings for CO_2 emissions growth—although this is not fully represented in the CO_2 emissions figures for nations because the emissions embedded in imported goods are not taken into account. Perhaps the success of the tourist industry contributed to such emissions growth in some of the southern European nations (and perhaps Thailand); if these tourists were from other nations, within the consumption perspective, this growth would be allocated to the tourists.

For the group of nations with high population growth rates and low CO_2 emissions growth rates, almost all are low-income countries, and many are among the lowest-income nations in the world and among those that had the least economic growth between 1980 and 2005. Some are reported to have had a decline in CO_2 emissions between 1980 and 2005, for instance, Chad, the Democratic Republic of the Congo, Liberia and Zambia.

Table 3.2 compares the different world regions with regard to their share of world population growth and CO_2 emissions growth between 1980 and 2005 and between 1950 and 1980. The table highlights the fact that sub-Saharan Africa accounted for very little of the growth in CO_2 emissions for both these periods (less than 3 per cent) but for 18.5 per cent of population growth between 1980 and 2005 and 10.7 per cent between 1950 and 1980. In contrast, Northern America accounted for around 4 per cent of population growth for both periods but for 20 per cent of the growth in CO_2 emissions in 1950-1980 and 14 per cent of the growth in emissions in 1980-2005. This is despite the fact that, in 1950, CO_2 emissions per person in Northern America were already very high (much higher than in many high-income nations today). Table 3.2 also includes figures for the five nations with the largest increases in CO_2 emissions. Note that China accounted for a much larger share of the increase in CO_2 emissions than India, but with a smaller contribution to increases in population. Japan, South Korea and the United States contributed far more to increases in CO_2 emissions than they contributed to increases in population. Note, too, that China and sub-Saharan Africa accounted for similar proportions of the increase in the world's population during the period 1980-2005 (15.3 and 18.5 per cent), but China's contribution to increased CO_2 emissions was nearly 20 times that of sub-Saharan Africa.

At the risk of unnecessary repetition, it is the number of consumers (and their consumption levels) that drives increases in GHG emissions, not the number of people (while from a production perspective, it is more the nature and location of production). Europe's share of CO_2 emissions growth is negative because many European nations had lower emissions in 2005 than in 1980, but if data were available for a consumption perspective analysis, this might well be different—with much higher proportions of emissions attributed to wealthy European nations (or, more correctly, to their wealthier citizens).

Table 3.2: Share of the World's Population Growth and CO_2 Emissions Growth, 1980–2005 and 1950–1980

		1980–2005		1950–1980	
		Share of population growth (%)	Share of CO_2 emissions growth (%)	Share of population growth (%)	Share of CO_2 emissions growth (%)
Regions	Africa, North	3.0	2.5	2.5	1.0
	Africa, sub-Saharan	18.5	2.4	10.7	2.2
	Asia	63.1	82.7	64.1	30.6
	Europe	1.8	-12.6	7.6	39.7
	Latin America and Caribbean	9.4	6.4	10.2	5.3
	Northern America	4.0	13.9	4.4	19.9
	Oceania	0.4	2.1	0.4	1.3
Nations	China	15.3	44.5		
	United States	3.4	12.6		
	India	21.7	9.9		
	Korea, Republic of	0.5	3.7		
	Japan	0.5	3.6		

Source: Derived from data from CAIT, 2009.

Table 3.3 shows the different contributions of nations to population growth and CO_2 emissions, 1980 to 2005 and 1950 to 1980, when they are classified by average per capita income levels. Nations classified as low-income in 2005 contributed far more to global population growth between 1950 and 2005 than they did to CO_2 emissions growth. Nations classified as high-income in 2005 accounted for far more CO_2 emissions growth than population growth. Again, if we shifted to a consumption-focused analysis, the contrasts between the nations contributing most to population growth and the nations contributing most to CO_2 emissions growth would be even more dramatic.

Table 3.3: Contributions to Population Growth and CO_2 Emissions Growth by Per Capita Income Category, 1980-2005 and 1950-1980

	1980–2005		1950–1980	
Income category in 2005	Population growth (%)	CO_2 emissions (%)	Population growth (%)	CO_2 emissions (%)
Low-income nations	52.1	12.8	36.0	5.6
Lower-middle income nations	35.7	53.2	47.1	39.7
Upper-middle income nations	5.0	5.0	5.7	9.6
High-income nations	7.2	29.1	11.2	45.1

Source: Derived from data from CAIT, 2009, and United Nations, 2008.

Population growth therefore can only be a significant contributor to GHG emissions if the people that make up this growth enjoy levels of consumption that cause significant levels of GHG emissions per person (or, from the production perspective, live in nations with a rapid increase in GHG-generating production). This, of course, has relevance not only for today but also for the future, in the lifetime contribution to GHG emissions of people born now. *If most of the growth in the world's population is among low-income households in low-income nations who never 'get out of poverty', then there is and will be little connection between population growth and GHG emissions growth.*

But even if a significant proportion of the future increase in GHG emissions is from nations with rapid population growth, if the increase is in nations below the 'fair share' level for average per capita emissions, it cannot be judged as comparable to that in nations above that level. More to the point, a growth in GHG emissions per capita among those individuals or households below the 'fair share' level (whatever the wealth of that nation) should be considered as qualitatively different from any growth in GHG emissions per capita among individuals or households above the 'fair share' level. Of course, this is very difficult to address, in part because of limited data, in part because it is difficult to support needed consumption increases among low-income groups while bringing down GHG emissions per person among groups above the 'fair share' level.

Perhaps the key issue to be gleaned from the above discussion is that far more attention needs to be given to changes in production and consumption within nations if we are to identify the main potential contributors to GHG emissions growth in the future. The main implications of Tables 3.2 and 3.3 are to caution against any assumption that population growth necessarily causes increases in CO_2 emissions. What is needed for any consideration of GHG emissions and population is a consideration of each nation's changes in production, in incomes and their distribution and in consumption. Of course, this is linked to urbanization because urbanization is driven by the increasing proportion of GDP generated by industry and services (most of which are located in urban areas) (Satterthwaite, 2007), while the form that urbanization takes is much influenced by the spatial distribution of investments in industry and services and the social and spatial distribution of the incomes arising from these economic changes. Demographic changes will be important influences, not only in terms of changes in the number of people but also in terms of changes in age structure and household size (and how these influence consumption).

This implies a need for caution against applying any generalization relating to climate change and population to 'developing countries' or even to particular regions (sub-Saharan Africa, for instance), because there will be such diversity between nations in almost all the factors that influence production and consumption patterns, as well as in a nation's possibilities to de-link CO_2 emissions from growing production and consumption (as in, for example, a nation that can draw on hydroelectricity for a significant proportion of demand for electricity).

Urbanization and Climate Change

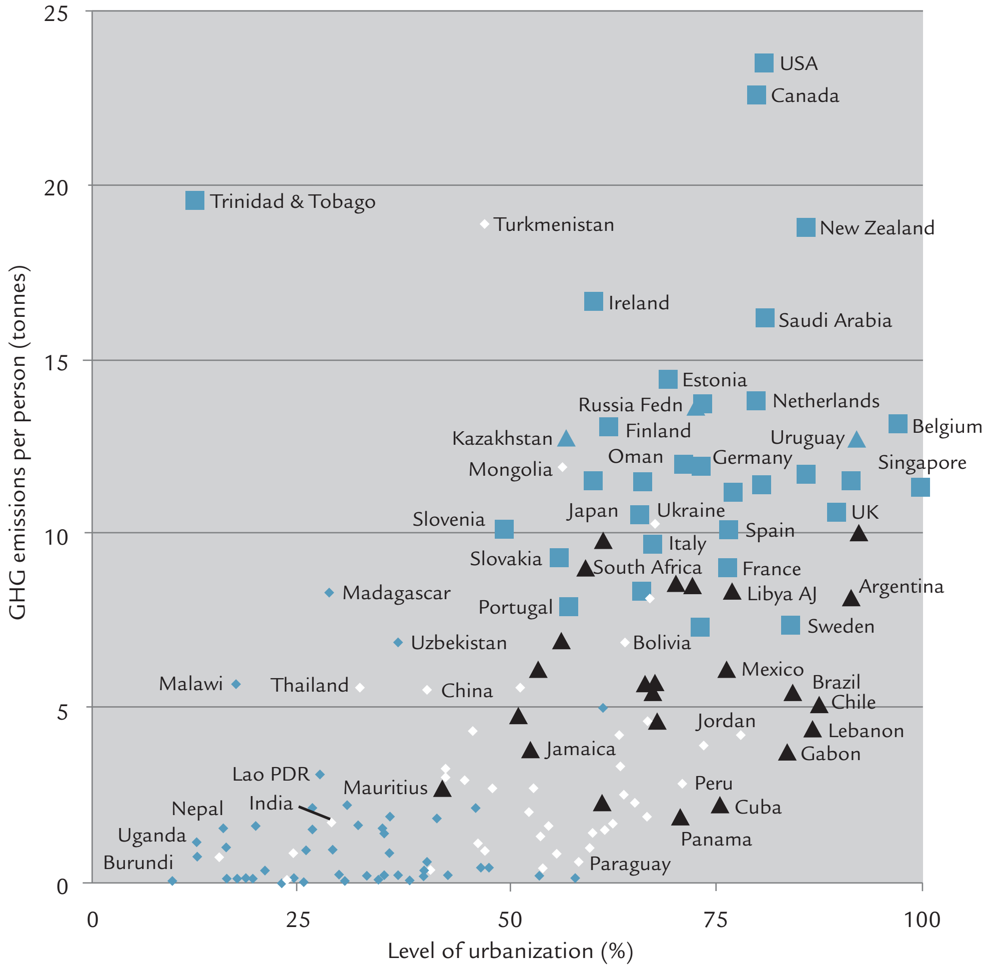
As noted, cities (or urbanization in general) are often held responsible for climate change. Sometimes this is based on estimates that seem to have no supporting evidence. This can be seen in the much-cited suggestion that cities account for 80 per cent of all GHG emissions worldwide. Actually, only around 35 per cent of the world's GHGs are emitted within city boundaries, although city populations account for a higher proportion of emissions if they are allocated to consumers (Satterthwaite, 2008). In other instances, the blame seems to be based on an assumption that urbanization brings higher GHG emissions—see, for instance, the assumption that per capita emissions in urban areas are higher than those in rural areas because of the ". . . big differences in productive and consumptive behaviours between rural and urban populations" (Jiang and Hardee 2009, p. 9). But this is certainly not always the case. With regard to consumption levels, in many nations, a large proportion of high-income, high-consumption households live in rural areas and are likely to have higher average GHG emissions per person or per household than urban-dwellers with comparable incomes—for instance, because of larger, less energy efficient homes and the greater use of (or, indeed, dependence on) private automobiles in rural areas. This explains in part why New York, London and Barcelona have much lower average GHG emissions per person than the national averages of the United States, United Kingdom or Spain, respectively (Chapter 4). This might be considered a phenomenon that is only common in high-income nations, but it is likely that a significant and often growing proportion of the high-income population in low- and middle-income nations now live outside urban boundaries. And, as already discussed, when viewing the energy use of low-income urban-dwellers in many low-income nations, it is not clear that their consumption patterns generate more GHG emissions than their rural counterparts.

Since most of the world's growth in population in the next few decades is likely to be in urban areas in low- and middle-income nations, the link between population growth and GHG emissions will be much influenced by the GHG emissions implications of urbanization in these countries. Urbanization can be viewed as one of the most serious 'problems' causing climate change in that, in general, the more urbanized a nation, the higher the GHG emissions per person. But it can also be viewed as a key part of the 'solution' in that it provides the basis for delinking high standards of living/quality of life from high GHG emissions per person. In the limited range of cities for which GHG emissions inventories have been undertaken, there are very large differences in per capita emissions among cities with high living standards. For instance, Barcelona, widely considered a city with a high quality of life, has one fifth of the GHG emissions per person of many cities in the United States. New York City has one third to one half of the GHG emissions per person of many other United States cities (Chapter 4). Many of the most desirable and expensive residential areas in or close to city centres in Europe have residential areas that are or can be made very energy efficient (typically terraces with three-to-six storey buildings), and settlement patterns and public transport systems that allow most trips to be made on foot, by bicycle or on public transport. Indeed, one of the drivers of urbanization is the economic advantages that close proximity provides for a great range of enterprises.

With regard to the impacts of climate change, urban areas can be seen as presenting one of the most serious 'problems', as they concentrate people and their assets, industries and infrastructure in ways that increase risk and vulnerability—and many cities and smaller urban centres are in locations that climate change is making (or will make) particularly hazardous (Bicknell et al., 2009). Conversely, urban areas can be viewed as having large potential advantages in building resilience to climate change impacts—i.e., in the economies of scale and proximity that they present for key protective infrastructure and services and for risk-reducing governance innovations to reduce risk and vulnerability, for instance, through partnerships between government agencies and civil society groups (Bicknell et al., 2009). It is also generally easier in urban than in rural areas to organize a rapid response to approaching extreme weather events that are judged serious enough to warrant moving many people temporarily from their homes.

Figure 3.1 shows the level of urbanization of selected nations plotted against per capita GHG emissions for 2005 (in CO_2e) based on the production perspective. The figure shows few surprises. In general, the more urbanized the nation, the higher the GHG emissions per person, although with considerable variations in emission levels per person for nations with comparable urbanization levels. Also, the wealthier the nation, the higher the GHG emissions per capita, although also with very considerable variations in GHG emissions per capita for nations with comparable levels of urbanization, and very considerable variations in levels of urbanization for nations with comparable GHG emissions per capita. Most low-income nations have less than half of their population in urban areas, and many have less than a quarter; many have per capita GHG emissions below 0.2 tonnes a year and very few above 2.5 tonnes a year. Of course, part of the large variations in GHG emissions per capita between nations with comparable levels of urbanization may be explained by the

Figure 3.1: Level of Urbanization of Countries plotted against Per Capita Greenhouse Gas Emissions (CO_2e) for 2005



Note: The small blue diamonds represent low-income nations, the small white diamonds lower-middle income nations, the black triangles upper-middle income nations and the large blue squares high-income nations. These figures include not only CO_2, but also the other greenhouse gases included in the Kyoto Protocol, and their contributions to global warming are converted into CO_2e.

different criteria used to define urban populations or urban places. But note that all of the upper-middle and high-income nations and many of the lower-middle income nations had GHG emissions per person above the ‘fair share’ level, with the United States and Canada having more than 10 times that level.

So, is urbanization a driver of climate change? It is generally assumed that it is, but urbanization cannot be the ‘driver’ in that it is itself propelled mainly by economic and political change. In almost all low- and middle-income nations, urbanization in the last few decades has been driven by investment patterns that have increased the proportion of production in industry and services (mostly located in urban areas) thereby increasing the proportion of the economically active population working in those industries and services. Increasing levels of urbanization therefore track the increasing proportions of GDP generated by industry and services and the growing proportions of the workforce employed therein (Satterthwaite, 2007). This strong association between growing levels of urbanization and changing investment/production patterns was less evident in many nations in Asia and Africa in earlier decades, around the time of the achievement of political independence, especially in countries where the rights of the population to live and/or work in urban areas had been controlled by the colonial government. Thus, much urbanization just pre- or post-independence resulted from the movement of individuals or households to urban centres that previously controlled their rights to live or work there, as well as from the building of the institutional infrastructure that is part of a nation-state. Here, then, political change was a major influence on increasing urbanization levels.[9]

From the production perspective, what drives the growth in GHG emissions in low-income and most lower-middle-income nations is the increasing use of fossil fuels in industries and services (and, usually, electricity generation). This is related to urbanization in the extent to which such production is within urban boundaries. For example, it is likely that the rapid growth in GHG emissions in cities such as Beijing and Shanghai is driven in large part by the very great expansion in manufacturing (Dhakal, 2004). Low-income nations that have little or no economic growth probably have little or no growth in GHGs in their urban areas, just as they generally have little or no increase in their urbanization levels (Potts, 2009). But for low- and middle-income nations that become wealthier (which also means becoming more urbanized), the location of consumers and the changes in their consumption behaviour become increasingly important contributors to GHG emissions. For instance, it can be assumed that, in India, it is generally urban areas with heavy industry that have the highest GHG emissions per person, but in particularly successful cities such as Delhi, Mumbai, Pune and Bangalore, GHG emissions per person may be increasingly driven by the consumption patterns of their higher-income groups (although this will only become fully apparent if city-based GHG emissions inventories can be done from the consumption perspective).

As noted already, in successful nations or successful cities, it is common for a growing proportion of middle- and upper-income households to live outside the city boundaries, in small urban centres or rural areas. In high-income nations there are also many manufacturing and service enterprises that are located in rural areas. But here, the division between rural and urban in terms of employment and access to infrastructure and services has disappeared; in effect, virtually all rural areas are 'urban' in that almost all of the population does not work in primary activities (including farming, forestry and fishing) and almost all enjoy levels of infrastructure and services that were previously only associated with urban locales. Thus, in high-income nations, there can be a large increase in per capita GHG emissions and very little or no increase in urbanization levels.

If the real driver of climate change is increasing consumption,[10] how can a more accurate understanding of the links between urbanization and climate change be achieved? It is known that allocating responsibility for GHG emissions through average per capita emissions figures for nations is misleading for at least two reasons. The first is that these figures are based on where GHGs are emitted and not on what caused them to be emitted. If GHG emissions were allocated to the location of the consumers whose consumption was the root cause of these emissions, it would considerably increase the GHG emissions per person in most high-income nations (and cities) and considerably decrease the GHG emissions per person in nations (and cities) that were successful exporters of consumer goods (especially those with high GHG emissions caused by their manufacture and transport to markets). The second is that it is very misleading to discuss responsibility for GHG emissions per person using national averages because of the very large differences in per capita emissions within each nation between the highest-income and lowest-income groups—perhaps a 100-fold or more difference between GHG emissions per person if the wealthiest 1 per cent and the poorest 1 per cent in many nations could be compared. As noted earlier, a proportion of the lowest-income households in rural and urban areas in many nations may not even have any net contribution to GHG emissions.

In summary, the real drivers of GHG emissions growth are high consumption and rapid growth in consumption, not population (or rapid population growth) or urbanization. If it was possible to assess GHG emissions by the consumption and lifestyles of households, it is likely that the very rich would have GHG emissions per person that were thousands of times greater than those of large sections of the poorest groups. If mapped on the whole world's population, irrespective of which nation they lived in, a figure would be produced that is similar to the 'champagne glass' used by the United Nations Development Programme's *Human Development Report* in 1992 to highlight global inequality in incomes, where the world's richest 20 per cent of the population receive at least 150 times the income of the poorest 20 per cent (UNDP, 1992).

Conclusions

It is not correct to suggest that it is the increase in population that drives the growth in GHG emissions, when the lifetime contribution to GHG emissions of a person added to the world's population varies by a factor of more than 1,000, depending on the circumstances into which he or she is born and his or her life possibilities and choices. It is not the growth in the number of people, but rather the growth in the number of consumers and the GHG implications of their consumption patterns that are the issue. In theory (leaving aside the difficulties in measurement), responsibility for GHG emissions should be with individuals and households and should be based on the GHG implications of their consumption, and not with nations (or cities) based on GHG inventories from the production perspective. From the consumption perspective, the 20 per cent of the world's population with the highest consumption levels is likely to account for more than 80 per cent of all human-induced GHG emissions and an even higher proportion of historical contributions. In considering how to reduce emissions globally, far more attention should be directed to reducing this group's GHG emissions. And, as responsibilities for addressing this are allocated to national and local governments (with city governments having particularly important roles), consideration should be given to the distribution among nations of this 20 per cent of the world's population (obviously most, but certainly not all, in high-income nations).

To obtain the much-needed rapid decrease in GHG emissions globally, there is an obvious need to focus on rapidly changing the consumption patterns of present (and future) consumers with above 'fair share' GHG emissions. With regard to development, the priority within energy policy is to support those living in 'energy poverty' (and its very serious health consequences) in moving to cleaner, more convenient fuels and in accessing electricity. While this will increase GHG emissions, it can nonetheless be achieved at emissions per person far below the 'fair share' level. It is only the high current and historical contributions of wealthy people's consumption to GHGs in the atmosphere that make the modest increases sought by low-income groups appear to be a problem.

This emphasis on allocating GHG emissions to consumers does not invalidate emissions inventories for cities based on the production perspective, as these serve to highlight particular sectors or activities with high GHG emissions and the high potential for reducing these. And as noted earlier, this production perspective has aspects of the consumption perspective, including GHG emissions linked to household energy use and transport (and usually also to electricity generation). There is now work under way to develop a common methodology for undertaking GHG emissions inventories that includes the consumption perspective, although this needs to be careful to subtract from city GHG emissions inventories the GHGs emitted in the production of goods that are exported from the city. Many of the key technologies for reducing GHG emissions, such as photovoltaic cells, windmills and motor vehicles with much reduced GHG emissions implications, will be produced in cities, and it would be misleading to allocate the GHG emissions used in their fabrication to these cities while the places in which they are used are credited with lower GHG emissions.

How the link between population growth and climate change is understood influences policy on sexual and reproductive health. Leaving aside the extreme positions—on one side, those opposing the provision of sexual and reproductive health services, including family planning; on the other, those demanding large reductions in population numbers as the only possibility for a 'sustainable' future—there is agreement on everyone's right to and need for good quality, accessible and affordable sexual and reproductive health services that include family planning. There is also a shared abhorrence for past coercive 'population control' measures. But beyond this, there are important differences.[11]

One is the different emphasis within development programmes between those who stress above all the need for more funding for family planning and those who stress the need for far more effective development programmes (that include good quality housing with good provision for water, sanitation, drainage, schools and health care and also greater legal protection for low-income groups and more possibilities for them to influence policies and hold government accountable). Of course, this focus on development includes support for family planning—but only recognizing this as one part of a good health care system and considering that unintended pregnancies are not simply the result of a lack of family planning but also of "... entrenched, gendered power dynamics at work within households, communities and nations worldwide" (Hartmann, 2008). A second difference is the stress on where investment in promoting behaviour change is needed, from those who emphasize the need for media campaigns to increase awareness of contraception and to foster a desire to use it, to those who stress the need for campaigns to "... challenge the overconsumption logic of global capitalism"(Hartmann, 2008) and its GHG implications.

It is the demographic changes associated with affluence or of increasingly affluent individuals, households and societies that are the most important demographic causes of the human-induced GHGs already present in the atmosphere and the most important drivers of their growth. From the consumption perspective, this is associated with urbanization only when an increasing proportion of consumption takes place in urban areas—which is only partly the case in high-income nations and perhaps in some middle-income nations (or areas within them) as well. And it is mostly in (responsibly governed) urban areas that it is possible to de-link a high quality of life from high GHG emissions per person. Whether or not population growth contributes to GHG emissions depends on the consumption patterns of those who make up this population growth.

Of course, from the perspective of adaptation to climate change, the critical issue in low- and middle-income nations is to reduce risks, with particular attention to doing so for vulnerable populations. But this has very strong complementarities with a successful development agenda and with the components noted above. There is an important 'population' component, in that it includes a high priority for ensuring that all individuals have good quality, affordable and easily accessible sexual and reproductive health services, within a larger commitment to ensuring other health care services, good environmental health, secure homes and adequate incomes. But this would not necessarily reduce GHG emissions.[12]

Notes

1 This is a condensed version of the paper of the same name published in *Environment and Urbanization* 21(2).

2 This is often labelled the 'production' perspective, but this implies that it is linked solely to what is produced when it also includes part of the consumption perspective—for instance, in fossil fuels used for transport and for heating buildings.

3 Apart, of course, from those appliances, such as radios, that can be powered by batteries.

4 It might be assumed that the use of fuelwood and charcoal by urban populations contributes to deforestation and thus to global warming, but detailed studies in the late 1980s showed that this assumption was not true in most instances (Arnold et al., 2006: Leach and Mearns, 1989).

5 Drawn from STATcompiler at http://www.statcompiler.com/, accessed June 15th 2009.

6 Using the US$1 a day poverty line, urban poverty appears to have decreased in many nations, but this poverty line is known to greatly understate the scale and depth of urban poverty because in many urban contexts, especially in successful cities in low- and middle-income nations, the costs of food and non-food needs (including rent for housing, payments for water and sanitation, school fees and costs for household energy, transport and health care) are much higher than US$1 a day (see: Satterthwaite, 2004).

7 CO_2e (carbon dioxide equivalent emission) is a measure of emissions where other greenhouse gases (such as methane) have been added to carbon dioxide emissions, with adjustments made for the differences in their global warming potential for a given time horizon.

8 This drew data from CAIT, 2009.

9 The influences of economic and political change on urbanization and how they and their relative importance have changed in low- and middle-income countries is discussed in more depth and detail in Satterthwaite, 2007.

10 Including the embedded energy in buildings and infrastructure.

11 See the discussion on population and climate change by a range of authors in: *Bulletin of the Atomic Scientists*, 2008.

12 The GHG emissions implications of directly meeting such needs would not be substantial and are unlikely to drive low-income nations into having per capita emissions above the 'fair share' level; however, if it is assumed that such needs are met by trickle down from economic growth, the GHG emissions implications would be far more serious.

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4

Urban Form, Greenhouse Gas Emissions and Climate Vulnerability

David Dodman

Introduction

This chapter presents an analytical review of the interaction among urban density, climate change and sea level rise. It focuses on two main themes: (1) the interaction between urban density and the generation of greenhouse gases and how this affects mitigation strategies; and (2) the consequences of climate change on urban settlements of varying population densities and how this affects adaptation strategies. Throughout, there is a recognition that changing population densities—and broader demographic issues—in urban centres can both affect and be affected by global environmental change.

First, as is already well known, climate change is caused by the emission of greenhouse gases, primarily from the combustion of fossil fuels. Greenhouse-gas-emitting activities are distributed in a spatially uneven manner. On the global scale, the 20 per cent of the world's population living in high-income countries account for 46.4 per cent of global greenhouse gas emissions, while the 80 per cent of the world's population living in low- and middle-income countries account for the remaining 53.6 per cent. The United States and Canada alone account for 19.4 per cent of global greenhouse gas emissions, while all of South Asia accounts for 13.1 per cent and all of Africa just 7.8 per cent (Rogner et al., 2007). This chapter therefore examines the implications of different urban densities for the emission of greenhouse gases (particularly, although not exclusively, in high-income countries) and the implications of this for global climate change. The relationships among the form, density, economy and society within cities are explored in order to assess whether particular spatial patterns can have a positive or negative effect on the emission of greenhouse gases and, consequently, on climate change.

Secondly, it is increasingly accepted that the effects of climate change will also be distributed unevenly. High urban densities can both contribute to and reduce the vulnerability of human populations. If populations are concentrated in vulnerable locations, without proper infrastructure or institutional frameworks, density can increase risk. However, if effective means can be found for supporting dense populations in safe locations with suitable infrastructural and institutional frameworks, a viable alternative to living on marginal and unsafe sites can be provided, particularly for the urban poor. Other aspects of demography, such as the gender and age composition of a population, also affect vulnerability. This chapter therefore examines patterns of urban density and vulnerability (particularly, although not exclusively, in low- and middle-income countries) and the inter-relationships between the two. Specifically, it examines case studies of high-population densities that increase exposure to the effects of climate change and vulnerability and case studies of high-population densities that can be seen to reduce risk. If well-managed, the increasing concentration of population in urban centres can result in a reduction in vulnerability to the direct and indirect impacts of climate change; if poorly managed, it can mean increasing levels of risk for large sections of the urban population.

These processes do not occur in isolation and cannot be separated from broader demographic, economic and social transformations. This chapter therefore approaches the interaction between climate change and urban density in a holistic manner that can identify appropriate, context-specific and policy-relevant recommendations. The analysis provided will help to strengthen capacity at the national and local levels to understand and deal effectively with urbanization in the face of the challenges posed by climate change.

Approaching Urban Density

Views of urban density have tended to be starkly polarized. Low-density cities are seen either to enable individual freedom and spacious living or to be a profligate and wasteful use of space and resources. Dense urban populations are considered to be indicative of claustrophobic squalor, poverty and deprivation, or of diversity and community. On the one hand, Ebenezer Howard's protests against urban overcrowding are still invoked: Howard argued that "[i]t is well nigh universally agreed by men of all parties . . . that it is deeply to be deplored that the people should continue to stream into the already overcrowded cities" (Howard, 1996, p. 346). On the other hand, Jane Jacobs' (1996) passionate defense of urban life in *The Death and Life of Great American Cities* is still taken as a mantra, particularly for those in the intellectual movement of 'new urbanism' who are opposed to the growth patterns of suburban sprawl and restrictive residential enclaves. For this latter group, low urban densities—frequently associated with the process of suburbanization—are often characterized as urban sprawl.

Both the definition and the effects of urban sprawl are widely debated. Frenkel and Ashkenazi (2008) identify five different systems for measuring sprawl—growth rates, density, spatial geometry, accessibility and aesthetic measures—with settlement patterns identified as sprawl when they meet one measure but not necessarily any of the others. Urban sprawl is often associated with a variety of social problems including "social isolation and obesity; asthma and global warming; flooding and erosion; the demise of small farms; extinction of wildlife and the unbalancing of nature" (Gottdiener and Budd, 2005, p. 148). In contrast, some planners see sprawl as inevitable or harmless, arguing that it maximizes the overall welfare of society as an outcome of free-market decision-making, provides easy access to open space and results in lower crime rates (Frenkel and Ashkenazi, 2008). But in many respects, the use of the term 'sprawl' has negative connotations and may serve to close spaces for discussion and negotiation. There is a clear need to move beyond these kinds of polarized positions and—as proposed later in this chapter—to accept a more nuanced view of the advantages and disadvantages of particular urban forms and levels of density.

In low- and middle-income countries, the related process of peri-urbanization is increasing. In the peri-urban interface, the boundaries between the 'urban' and the 'rural' are continually being renegotiated and, rather than being clearly defined, are characterized by transition zones. These interfaces are affected by some of the most serious problems of urbanization, including intense pressures on resources, slum formation, lack of adequate services such as water and sanitation, poor planning and degradation of farmland. They are of particular significance in low- and middle-income countries, where planning regulations may be weak or weakly enforced and therefore result in areas with complex patterns of land tenure and land use (McGregor et al., 2006; Tacoli, 2006). Although peri-urban areas provide a variety of activities and services for urban centres, they are generally beyond or between the legal and administrative boundaries of these cities, with the result that the process of urbanization can be unplanned and informal with frequent struggles over land use.

The relationship between urban population density and the environment in its broader sense is further complicated by the spatial displacement of environmental costs. Although it is often argued that denser urban settlements make more efficient use of land and other resources, at least some of this can be attributed to their 'ecological footprints' outside the spatial boundaries of the city (Wackernagel and Rees, 1995; Wackernagel et al., 2006). This displacement of environmental costs is particularly relevant to climate change when 'consumption-based' rather than 'production-based' measures of greenhouse gas generation are utilized. Many cities in North America and Europe are service-oriented rather than production-oriented, yet traditional mechanisms for identifying the source of greenhouse gas emissions allocates these to the location of production, rather than to the location of the consumption of the finished product (Bai, 2007).

At its simplest, urban density is measured by dividing a given population by a given area. The widely varying definitions of the spatial extent of urban areas lead to a great deal of difficulty in generating comparable statistics for different towns and cities. Dividing the population of a metropolitan area by the administrative areas contained within its official boundaries is a highly unreliable measure—particularly for comparisons—because the density will vary according to the definition of these boundaries (Angel et al., 2005). In addition, standard measures of density are calculated over an entire land area, without taking into account the levels of connectivity. For example, the gradual transformation of the urban form of Curitiba, Brazil, from a predominantly radial-circular form to a more linear pattern of development has reduced the city's overall density, yet it has facilitated the development of a more rapid and effective public transportation system and produced various other social and environmental benefits.

At the global level, however, there is strong evidence that urban densities have generally been declining over the past two centuries (UNFPA, 2007). Perhaps the most detailed and compelling assessment of this phenomenon is provided by a recent World Bank report (Angel et al., 2005). This report used a method of measuring the density of the *built-up* area (as defined through satellite imagery) rather than the *administrative* area of cities, and applied this to a total of 3,943 cities with populations greater than 100,000. These cities had a total population of 2.3 billion people: 1.7 billion in 'developing' countries and 0.6 billion in 'industrialized' countries. According to the report, the average density of cities in industrialized countries in 2000 was 2,835 people per km^2, declining from 3,545 people/km^2 in 1990, with an annual change of -2.2 per cent. In developing countries, the average urban population density in 2000 was 8,050 people/km^2, declining from 9,560 people/km^2 in 1990, with an annual change of -1.7 per cent. Alternatively, these figures can be expressed as the average built-up area per person: $125m^2$ in developing country cities and $355m^2$ in industrialized country cities.

Table 4.1: Average Density of Built-up Areas (persons per km^2)

	1990	2000
Less-developed Countries	9,560	8,050
Industrialized Countries	3,545	2,835
East Asia and the Pacific	15,380	9,350
Europe	5,270	4,345
Latin America and the Caribbean	6,955	6,785
Northern Africa	10,010	9,250
Other Developed Countries	2,790	2,300
South and Central Asia	17,980	13,720
South-East Asia	25,360	16,495
Sub-Saharan Africa	9,470	6,630
Western Asia	6,410	5,820
Low Income	15,340	11,850
Lower-middle Income	12,245	8,820
Upper-middle Income	6,370	5,930
High Income	3,565	2,855

Source: Adapted from Angel et al., 2005.

This trend of reduced urban densities is likely to continue into the future. It is estimated that the total population of cities in developing countries will double between 2000 and 2030, but their built-up areas will triple (from approximately 200,000 km^2 to approximately 600,000 km^2); in industrialized countries, the urban population will increase by approximately 20 per cent, while their built-up areas will increase 2.5 times (from approximately 200,000 km^2 to approximately

500,000 km^2). The agglomerated figures for industrialized and developing countries conceal a great deal of regional variation (see Table 4.1). In 2000, South-East Asian cities were almost four times as densely populated as European cities, and almost eight times as densely populated as those in 'Other Developed Countries' (including North America and Australasia). These figures can also be disaggregated by income levels: Cities in low income countries are more than four times as densely populated as cities in high-income countries.

In summary, the average density of built-up areas in all cities, in all regions and of all population sizes is decreasing. As has been shown, however, this is a highly uneven process. Larger cities tend to exhibit higher densities than smaller cities (McGranahan et al., 2007), and these figures do not capture the variations in density that exist within cities. Although the density for any given urban area as a whole may be declining, there are still likely to be pockets of extremely high density, and these are likely to be associated with low-income residential areas. The following sections of this chapter assess the relationship between these patterns of urban density and the different aspects of climate change in a greater level of detail.

Urban Density and Greenhouse Gas Emissions

Urban form and urban spatial organization can have a wide variety of implications for a city's greenhouse gas emissions. The high concentrations of people and economic activities in urban areas can lead to 'economies' of scale, proximity and agglomeration that can have a positive impact on energy use and associated emissions, and the proximity of homes and businesses can encourage walking, cycling and the use of mass transport in place of private motor vehicles (Satterthwaite, 1999). Some researchers suggest that each doubling of average neighbourhood density is associated with a 20-40 per cent decrease in per-household vehicle use and a corresponding decline in emissions (Gottdiener and Budd, 2005, p. 153). Newman and Kenworthy (1989), for example, suggested that gasoline use per capita declines with urban density (although they acknowledged that the correlation weakens once GDP per capita is taken into account), and Brown and Southworth (2008, p. 653) argue that "by the middle of the century the combination of green buildings and smart growth could deliver the deeper reductions that many believe are needed to mitigate climate change".

Yet cities have often been blamed for generating most of the world's greenhouse gas emissions and for contributing disproportionately to global climate change. Referring specifically to climate change, the Executive Director of the United Nations Centre for Human Settlements (UN-HABITAT) has stated that cities are "responsible for 75 percent of global energy consumption and 80 percent of greenhouse gas emissions"; while the Clinton Foundation suggests that cities contribute "approximately 75 percent of all heat-trapping greenhouse gas emissions to our atmosphere, while only comprising 2 percent of land mass" (For references to these and similar quotations, and a detailed critique, see Satterthwaite, 2008). At the same time, detailed analyses of urban greenhouse gas emissions for individual cities suggest that, per capita, urban residents tend to generate a substantially smaller volume of carbon emissions than residents elsewhere in the same country (Dodman, 2009). Indeed, per capita emissions in New York City are only 29.7 per cent of those in the United States as a whole (PlaNYC, 2007); those in London are just over half of the British average (Mayor of London, 2007); those in Rio de Janeiro are only 28.0 per cent of those of Brazil as a whole (Dubeux and La Rovere, 2007); and those in Barcelona are only 33.9 per cent of those of Spain as a whole (Baldasano et al., 1999). These relatively low levels of emissions are influenced by a variety of factors—including the density of buildings, the average dwelling unit size and the extent of public transportation—several of which are linked directly to patterns of urban density.

Dense urban settlements can therefore be seen to enable lifestyles that reduce per capita greenhouse gas emissions through the concentration of services that lessens the need to travel long distances, the (generally) better provision of public transportation networks and the constraints on the size of residential dwellings imposed by the scarcity and high cost of land. Yet conscious strategies to increase urban density may or may not have a positive effect on greenhouse gas emissions and other environmental impacts. Many of the world's most densely populated cities in South, Central and South-East Asia suffer severely from overcrowding, and reducing urban density would meet a great many broader social, environmental and developmental needs. High urban densities can cause localized climatic effects such as increased local temperatures (Coutts et al., 2007). In addition, a variety of vulnerabilities to climate change are exacerbated by density: Coastal location, exposure to the urban heat-island effect, high levels of outdoor and indoor air pollution and poor sanitation are associated with areas of high population density in less-developed-country cities (Campbell-Lendrum and Corvalán, 2007). However, there are clear opportunities for simultaneously improving health and cutting GHG emissions through policies related to transport systems, urban planning, building regulations and household energy supply.

Conversely, some of the apparent climate change mitigation benefits of high urban densities in industrialized countries may be a consequence of the spatial displacement of greenhouse-gas-generating activities to other locations within the same country or internationally. Reducing greenhouse gas emissions—or addressing climate change mitigation—can only be meaningfully achieved through a process of reducing both direct and indirect emissions.

Policy implications: Density and 'climate friendly cities'

Although the relationship between urban density and greenhouse gas emissions is complex, there are certain lessons that can be identified as relevant for urban policy. These do not amount to wholesale recommendations in favour of densification, but rather look at strategically assessing population distribution in a manner that contributes to broader goals of climate change mitigation. Encouraging densification at an aggregate scale—within administrative boundaries, for example—risks neglecting the important environmental and social roles played by gardens and open spaces. It is also worth considering the different housing needs for individuals at different stages of life and reconsidering the notion of 'housing for life' that has been prevalent in many national housing policies (Minerva LSE, 2004). In this regard, dense settlement patterns may meet the needs of certain groups within society, but not others.

In general, however, density does provide the potential for access to and use of public transportation—when designed to meet the needs of users. A report by Minerva LSE (2004) shows a "positive link between higher-density areas and levels of public-transport access across London, which is reflected in the decisions that people make about how to get to work" (p. 4). It further concludes that "on balance, people will use public transport where it is available, especially in high density, centrally located areas". This case study of London also shows how high density areas can accommodate both deprived and affluent communities, in which there is a shared willingness to live in economically successful parts of the British capital at high densities. People appear to 'trade off' more space in their homes for other qualities, such as personal and property safety, the upkeep of the area and proximity to shops and amenities.

Access to public transportation need not imply high density, as shown by the concepts of 'transit-oriented development' and 'transit villages' pioneered in California (California Department of Transportation, 2002). They are characterized by moderate- to high-density housing within easy walking distance of major transit stops. Similar processes can be facilitated in low- and middle-income nations through the development of bus rapid transit systems. These are most efficient in servicing densely populated linear developments, which contain a large number of urban residents who live within walking distances of the main trunk routes. The first comprehensive example of this type of development began in Curitiba, Brazil, in the mid-1970s; Curitiba now has an integrated public transport system focused on five main 'axes' that is used by two thirds of the city's population (Rabinovitch, 1992). More recently, the TransMilenio public transportation system was developed in Bogotá, Colombia (Héron, 2006). It is also based on a trunk-route system with feeder services, which does not necessarily imply consistently high urban densities. However, it has been successful at meeting the needs of the 80 per cent of the city's population who are dependent on public transportation, including the 53 per cent who are defined as living in poverty.

These examples from North and South America show that innovative thinking in relation to the planning of transportation infrastructure can meet both environmental and social needs. Localized areas of relatively high densities are required to generate greater efficiencies in the use of public transportation, but this can be consistent with meeting a variety of other demands from urban residents. Of course, the precise form that these transportation networks—and other urban networks (for supplying electricity, water, etc.)—should take requires detailed local study. Overall, however, density is one of several factors that affect energy use—and by extension greenhouse gas emissions—in towns and cities. Addressing these issues requires ongoing analysis of *urban processes,* rather than simply taking a snapshot of *urban form* at a particular moment in time.

Urban Density and Climate Change Vulnerability

A second major interrelationship between population density and climate change is in patterns of density and vulnerability. Densely populated urban areas—especially in low- and middle-income countries—are particularly vulnerable to the effects of climate change. Where there are dense concentrations of households and economic activities, the effects of climate change can impinge on large numbers of people and have a major impact on urban economies—even if they affect only relatively small land areas. However, if appropriate infrastructure is developed in areas that are less likely to be influenced by climate change, an opportunity to build large-scale resilience could be provided in a relatively cost-effective manner.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report of 2007 unequivocally states that the earth's climate system has been undergoing warming over the last 50 years. Projections of future global average surface warming (for the decade 2090-2099 relative to 1980-1999) range from 1.1° to 6.4°C, whilst sea level rise is predicted at 18 to 59cm (IPCC, 2007). Mean temperatures are likely to increase, mean precipitation will fluctuate and mean sea level will rise; extreme rainfall events and tropical cyclones are likely to be more frequent and intense, leading to more frequent flooding (both riverine and storm surge). Climate change is likely to exacerbate many of the risks faced by low-income urban residents: The IPCC states that "poor communities can be especially vulnerable, in particular those concentrated in relatively high-risk areas" (Wilbanks et al., 2007, p. 359). Urban areas in low- and middle-income nations already house a large percentage of the people and economic activities most at risk from climate change, including extreme weather events and sea level rise, and this proportion is increasing.

The main impacts of climate change on urban areas, at least in the next few decades, are likely to be increased levels of risk from existing hazards. For poorer groups, these will include direct impacts such as more frequent and more hazardous floods; less direct impacts such as reduced availability of freshwater for many cities that may limit the supplies available to poorer groups; and indirect impacts such as the effects of climate-change-related weather events that increase food prices or damage poorer households' asset bases (Dodman and Satterthwaite, 2008).

Urban population density, climate change and disasters

The dense concentration of urban populations can increase susceptibility to the disasters that are likely to become more frequent and more intense as a result of climate change. Economies, livelihoods, physical infrastructure and social structures are all important components of urban systems and are vulnerable to disasters and climate risk in different ways. However, far more is known about the environment of risk (the factors leading to vulnerability) than of the risk impact (the number of deaths and serious injuries and the damage to property and livelihoods when disasters occur). But the (limited) available evidence suggests that the number of serious injuries and deaths from disasters in urban areas has been growing in most low- and middle-income nations (UN-HABITAT, 2007).

Dense urban populations in high-income nations take for granted a web of institutions, infrastructure, services and regulations that protect them from disasters—including extreme weather, floods, fires and technological accidents. Many of the measures to protect against these involve services that also supply everyday needs, including health care services integrated with emergency services and sewer and drainage systems that meet daily requirements but that can also cope with storms. Almost everyone lives and works in buildings that meet health and safety regulations and that are served by infrastructure designed to cope with extreme weather. The police, armed services, health services and fire services, if or when needed, provide early warning systems and ensure rapid emergency responses. Consequently, extreme weather events rarely cause a large loss of life or serious injury. Although occasionally such events cause serious property damage, the economic cost is reduced for most property owners by property and possessions insurance. In contrast, only a very small proportion of urban centres in low- and middle-income nations have a comparable web of institutions, infrastructure, services and regulations, although there are very large variations among such centres in the extent of provision and coverage. The proportion of the population in cities that lives in legal homes built according to appropriate building regulations varies widely, as does the proportion of the population living in homes adequately served by sanitation, wastewater removal and storm drains (Hardoy et al., 2001).

However, the fact that disasters often have a disproportionate impact on areas of high population density does not necessarily mean that density itself is to blame for increasing vulnerability. Rather, it is the fact that inadequate institutions and lack of infrastructure are often concentrated in areas where there are also high population densities of low-income urban residents. In and of itself, reducing density is not a solution to reducing vulnerability to climate-change-related disasters: after all, many poor, dispersed, rural populations also suffer horrendously from climatic and other disasters. Instead, reducing vulnerability to climate change in high density urban settlements requires the provision of adequate infrastructure and services. Given the necessary political will and financial resources, this can be achieved relatively economically in dense settlements, as any improvements made can benefit a large number of people.

Low-income groups often have no choice but to settle on already densely populated marginal land, as no other suitable land is available. Because of this, one particularly important response to urban climate change vulnerability is to make adequate and appropriately located land available to low-income urban groups. This approach has been implemented successfully in the city of Manizales in Colombia, which has managed to avoid rapidly growing low-income populations settling on dangerous sites (Velásquez, 2005). The population of Manizales was growing rapidly, with high levels of spontaneous settlement in areas at risk from floods and landslides. Local authorities, universities, non-governmental organizations and communities worked together to develop programmes aimed not only at reducing risk, but also at improving the living standards of the poor. Households were moved off the most dangerous sites and re-housed nearby. Most of the former housing sites were converted into eco-parks with strong environmental education components. A similar approach was implemented in the city of Ilo in Peru (Díaz Palacios and Miranda, 2005). Although the city's population increased fivefold between 1960 and 2000, there have been no land invasions or occupations of risk-prone areas by poor groups, because local authorities have implemented programmes (such as the acquisition of an urban-expansion area) to accommodate this growth and to support the poor in their efforts to achieve decent housing. At the same time, improvements were made in water supply, sanitation, electricity provision, waste collection and the provision of public space. Similar interventions—with a strong focus on providing safe and accessible land for high density housing for the urban poor—are required to reduce climate change vulnerability in densely populated towns and cities around the world.

Urban population density, climate change and health

Climate change is also likely to affect human health in urban centres. This is of particular concern in the Least Developed Countries, which already experience a high burden of climate-sensitive diseases. Many of these health risks are exacerbated in densely populated urban areas. In addition to the direct mortality effects of more frequent and extreme weather events, climate change will also affect human health through changes in vector-borne disease transmission, increased malnutrition due to declining food yields and increases in diarrhoeal diseases from changes in water quality and water availability. This is a highly inequitable situation, as those who are at greatest risk are also those who have contributed the least to greenhouse gas emissions.

Climate change is likely to result in more frequent and intense heat waves. In cities, these are exacerbated by the urban heat-island effect as a result of lower evaporative cooling and increased heat storage in roads and buildings, which can make temperatures 5-11°C warmer than in surrounding areas. Heat waves can have dramatic impacts on human health: The European heat wave of August 2003 caused excess mortality of over 35,000 people (Campbell-Lendrum and Corvalán, 2007). Heat waves can result in significant deleterious economic effects due to decreased productivity and the additional cost of climate-control within buildings, as well as generating 'knock-on' environmental effects, such as air pollution and increased greenhouse gas emissions if these cooling needs are met with electricity generated from fossil fuels (Satterthwaite et al., 2007). There is also some evidence that the combined effects of heat stress and air pollution may be greater than the apparent additive effect of these two stresses (Patz and Balbus, 2003). The effects of heat stress are distributed unevenly within urban populations, with elderly persons being especially vulnerable.

As noted, densely populated urban areas may become increasingly vulnerable to vector-borne diseases due to climate change, as shifting climate patterns extend the range of certain vectors. In general, the higher rates of person-to-person contact in dense urban settlements can help to spread infectious diseases more quickly. Rapid unplanned urbanization can produce breeding sites for mosquitoes, high human population densities can provide a large pool of susceptible individuals, and higher temperatures can cause an increase in high absolute humidity that can also extend the species' range (Campbell-Lendrum and Corvalán, 2007). Diseases spread in this way include dengue fever, malaria and filariasis. However, although climate change is likely to result in the expansion of malaria-carrying mosquitoes to some new locations, it is likely to cause the contraction of this range in other areas (Confalonieri et al., 2007).

But the effects of climate change on human health in densely populated urban settlements are not insurmountable. Indeed, although the current burden of climate-sensitive disease is highest among the urban poor, it is not the rapid development, size and density of cities that are the main determinants of vulnerability, but rather the increased populations living in hazard zones, flood plains, coastal hazard risk zones and unstable hillsides vulnerable to landslides. In the next few decades, good environmental and public health services should be able to cope with any increase in climate-change-related health risks—whether caused by heat waves or reduced fresh-water availability or greater risks from communicable diseases. However, providing these services requires firm commitments to build the necessary infrastructure on the part of municipal and national governments, as well as on the mobilization of appropriate financial resources to facilitate this.

In Durban, South Africa, the eThekwini Municipality identifies human health as a key component of its 'Headline Climate Change Adaptation Strategy' (Roberts, 2008). This strategy recognizes that the municipal government will have to respond to greater risks of heat-related deaths and illnesses, extreme weather (particularly the vulnerability of sewage networks and informal settlements to flooding), potentially reduced air quality and the impacts of changes in precipitation, temperature, humidity and salinity on water quality and vector-borne diseases. It also recognizes the 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, to develop an extreme-climate public early-warning system and to facilitate research and training on environmental health.

Policy implications: Maintaining density whilst reducing vulnerability

As was clearly shown in the first sections of this chapter, de-densification of urban areas can lead to increasing greenhouse gas emissions—particularly related to the additional energy required for transportation. A particular challenge for urban planners and managers in low- and middle-income nations is to improve the quality of housing—and thereby increase resilience—for low-income urban residents living in inadequate shelter (meeting adaptation needs), whilst maintaining generally high density levels (meeting mitigation needs). What is certain, however, is that attempts at preventing urban growth by discouraging rural-urban migration with tactics such as evicting squatters and denying them services are futile, counter-productive and violate people's rights (UNFPA, 2007).

There are various strategies for improving slum settlements, including through investments by individuals and households and upgrading driven by community-neighbourhood investment and by external programmes. However, individuals and households cannot address the need for infrastructure at the scale of the neighbourhood (water pipes, sewers and drains, paved roads and paths, electricity, social services), and the most successful upgrading involves a combination of community/resident organizations and government agencies acting to address these issues. In many cases, as shown in the examples below, this approach can maintain densities whilst reducing vulnerability.

In Thailand, the Baan Mankong process constitutes a national approach to upgrading and providing secure tenure (Boonyabancha, 2005). In some cases, slum upgrading actually *increases* densification: In Charoenchai Nimitmai, the re-blocking process accommodated new residents as a means of reducing land costs. Technical solutions that facilitate maintaining density while also improving resilience can include in situ improvement, re-blocking, land-sharing and nearby relocation. However, Boonyabancha concluded (p. 39) that "finding technical solutions . . . is the easy part". The broader lessons learned from the Baan Mankong process are related to the importance of citywide programmes in which urban poor organizations are fully involved; the importance of horizontal linkages between peer groups in the city; and the importance of enhancing the 'belonging' of urban poor groups.

In Namibia, progressive policies for slum upgrading involved reducing the official national minimum plot standard, thereby expanding the legal options for increasing densities (Mitlin and Muller, 2004). Instead of a minimum standard of 300m^2, the option was provided for serviced plots of 180m^2 with communal water points and gravel roads. Frameworks were also provided that facilitated group purchase or lease of communally serviced land and smaller plot sizes, meaning that families can live legally while upgrading services as and when this can be afforded.

An additional aspect of slum upgrading and densification that needs to be addressed is the design of low-income housing. Nnaggenda-Musana (2008) suggests that most 'low-cost' housing design proposals are little more than smaller versions of higher income housing designs, resulting in sprawling low-cost housing that leads to longer travel distances for low-income urban residents and increased costs for the provision of services and infrastructure. Longer travel distances increase both emissions and cost problems. New house types for low-income households can reduce infrastructure and transport costs while at the same time preventing encroachment on agricultural land. In addition, architects have rarely learned from the strategies used by urban poor households to keep their buildings as comfortable as possible in a range of climate scenarios; Jabeen

(2009) shows some of the strategies used by households in Dhaka, Bangladesh, to keep indoor temperatures relatively cool, even when outdoor temperatures are particularly hot.

Conclusion

Urban areas, particularly in low- and middle-income nations, face a variety of challenges. Perhaps the most striking is the tension between meeting the twin demands of generating urban economic growth and meeting the needs of low-income urban residents (Parnell and Robinson, 2006; Pieterse, 2008). These issues are related to a variety of climate change challenges as well, particularly in regard to ensuring that urban growth occurs in a 'climate friendly' manner and that urban housing and infrastructure are 'climate proof'. Deeper consideration of demographic issues and their implications for mitigation and adaptation can help to resolve these tensions.

This chapter has examined the relationship between urban density and climate change, and has considered this relationship from the perspectives of both mitigation and adaptation to climate change. Future patterns of greenhouse gas emissions and the consequent climate change will be driven substantially by the activities now taking place in urban areas; similarly, the ways in which climate change impacts the lives and livelihoods of more than half of the world's population will also be mediated through actions that are taken—or not taken—in towns and cities. It is clear that there is no 'ideal size' for urban settlements—indeed, "different sizes and shapes of cities imply different geographical advantages" (Batty, 2008, p. 771). In addition, there is no ideal density for cities and towns—instead, broader issues of urban form and structure are equally or more important.

There is also a complex series of interactions among urban density, economic status and greenhouse gas emissions. The residents of the densely populated cities of low- and middle-income countries are generally wealthier than residents of the hinterlands, yet they are far less wealthy than residents of the less densely populated cities in high-income countries. This illustrates that the relationship between urban density and greenhouse gas emissions is not straightforward: In low-income countries, residents of denser settlements are likely to have higher per capita emissions as a function of their greater wealth than residents of surrounding areas, whereas in high-income countries, residents of denser settlements are likely to have lower per capita emissions than residents of surrounding areas as a result of smaller housing units and greater use of public transportation systems.

In relation to the impacts of, and adaptation to, climate change (and other environmental hazards), density has another set of effects. The extremely high population densities of many urban areas in low- and middle-income countries contribute to environmental health problems and may concentrate risk in particularly vulnerable locations, and any potential sustainability gains from even greater densification are likely to be limited. Indeed, "under these circumstances the merits of urban densification postulated for developed country cities seem far less convincing in the context of developing countries" (Burgess, 2000, p. 15).

In summary, density is one of several major components affecting the ways in which urban areas will both influence and be affected by a changing climate. Adopting 'increasing densification' as a strategy without assessing other factors such as the distribution of employment opportunities and the nature of transportation systems is not likely to provide lasting sustainability or resilience benefits. Yet, in association with a wider awareness of urban form and process, well-planned, effectively-managed and densely-settled towns and cities can help to limit greenhouse gas emissions and facilitate resilience to the challenges of climate change.

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5

Mapping Urban Settlements and the Risks of Climate Change in Africa, Asia and South America

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Introduction

United Nations forecasts of urban population growth suggest that over the quarter-century from 2000 to 2025, low- and middle-income countries will see a net increase of some 1.6 billion people in their cities and towns, a quantity that vastly outnumbers the expected rural population increase in these countries and which dwarfs all anticipated growth in high-income countries (United Nations, 2008). In the 25 years after 2025, the United Nations foresees the addition of another 1.7 billion urban-dwellers to the populations of low- and middle-income countries, with the rural populations of these countries forecast to be on the decline. Where, precisely, will this massive urban growth take place? Is it likely to be located in the regions of poor countries that appear to be environmentally secure or in regions likely to feel the brunt of climate-related change in the coming decades?

This chapter documents the current locations of urban-dwellers in Africa, Asia and South America in relation to two of the ecologically delineated zones that are expected to experience the full force of climate change: the low-elevation coastal zones and the arid regions known to ecologists as drylands. Low-lying cities and towns near the coast will most probably face increased risks from storm surges and flooding; those in drylands are expected to experience increased water stress and episodes of extreme heat. Climate-related hazards will present multiple threats to human health, as described in more detail in Chapter 10. The risks are likely to be especially severe in the cities and towns where private and public incomes are low and protective infrastructure is lacking.

To assess the risks that global climate change presents for urban-dwellers in poor countries, it is obviously of vital importance to know enough about the locations of people who will be exposed to these hazards and for the most vulnerable among them to be identified and given priority. Planning for improvements in urban drainage, sanitation and water supply requires both spatial and population data, as do forecasts of where urban fertility and migration will augment the populations of towns and cities in the path of risk. National economic strategists need to be made aware of the implications of locating special economic zones and promoting coastal development in what will become environmentally risky sites. Until recently, however, the data needed to create a global map of the populations exposed to climate-related risks had not been drawn together.

The essential ingredients for such a map have been assembled over the course of a large-scale collaborative effort involving the United Nations Population Division, the Global Rural-Urban Mapping Project (GRUMP), housed at the Socioeconomic Data Applications Center at Columbia University's Earth Institute, and researchers based at the City University of New York and the Population Council. For every low- and middle-income country, population data can now be mapped according to the most finely-disaggregated administrative units that the research team could obtain. For cities with a population of 100,000 and above, information on population growth over time has been drawn from the most recent version of the United Nations Population Division's cities database (United Nations, 2008). The reach of the data has been extended to include hundreds of additional observations on small cities and towns (accounting for a significant percentage of all urban residents), which were collected in the 2008–2009 update of GRUMP (SEDAC, 2008; Balk, 2009). Each urban settlement in the combined data set is located in spatial terms by latitude and longitude coordinates, and also by an overlay indicating the spatial extent of the urban agglomeration, which is derived from remotely-sensed satellite imagery (Elvidge et al., 1997; Balk et al., 2005; Small et al., 2005). With their locations having been pinpointed, it becomes possible to determine whether all or part of city and town populations are situated in the low-elevation and drylands ecozones. To assess the likely pace of urban growth in these zones, the United Nations' city time-series are used, supplemented by a large collection of demographic surveys covering the period from the mid-1970s to the present. The latter supply additional information on urban fertility and mortality rates.[2]

In an earlier analysis, McGranahan et al. (2007) showed how data such as these could be combined to estimate the number of rural- and urban-dwellers worldwide who live in coastal areas within 10 metres of sea level—the low-elevation coastal zone (LECZ)—an elevation that is above the currently predicted rise in sea levels but which often lies within the reach of cyclones, storm surges and other indirect impacts of sea level rise. With the benefit of several additional years of data collection, it is now possible to refine the coastal zone analysis and extend it to cover urban residents of the drylands ecosystems, whose total population substantially exceeds that of coastal zones.

The remainder of this chapter is organized as follows: In the first section the health implications of climate-related hazards in low-lying coastal areas and drylands are reviewed. In the second, the GRUMP data are employed to calculate the numbers of urban-dwellers who currently live in areas where these hazards are likely to be pronounced. For selected countries, data from the World Bank's Small-Area Poverty Mapping project are used to identify where the communities of the urban poor are located in relation to the LECZ. Next, to indicate how urban exposure and vulnerability are likely to be reshaped by future population growth, estimates and forecasts of city population growth rates are presented by ecozone for the major regions of the developing world, in this case using the city time-series provided by the United Nations. The chapter concludes with a discussion of how such information could advance the efforts of cities and towns to adapt to climate change.

Urban Risks in Low-elevation Coastal Zones and Drylands

Because seaward hazards are forecast to increase in number and intensity as climate change takes hold, and coastal areas are disproportionately urban, it is especially important to quantify the exposure of urban residents in low-elevation coastal zones, and to understand the likely implications for their health. The other vulnerable ecosystem—drylands—contains (globally) far larger populations than found in the LECZs. Much of the discussion of climate change for drylands has focused on the rural implications—but what will it mean to be an urban resident of the drylands?

The low-elevation coastal zone

According to current forecasts, sea levels will gradually but inexorably rise over the coming decades, placing large coastal urban populations under threat around the globe. Alley et al. (2007) foresee increases of 0.2 to 0.6 metres in sea level by 2100, a development that will be accompanied by more intense typhoons and hurricanes, storm surges and periods of exceptionally high precipitation. Many of Asia's largest cities are located in coastal areas that have long been cyclone-prone. Mumbai saw massive floods in 2005, as did Karachi in 2007 (Kovats and Akhtar, 2008; The World Bank, 2008). Storm surges and flooding also present a threat in coastal African cities (e.g., Port Harcourt, Nigeria, and Mombasa, Kenya[3]) and in Latin America (e.g., Caracas, Venezuela, and Florianópolis, Brazil[4]). As explained in Chapter 10, a coastal flood model used with the climate scenarios developed for the Intergovernmental Panel on Climate Change (IPCC) suggests that the populations of the areas at risk, and the income levels of these populations, are critical factors in determining the health consequences of such extreme-weather events.

Urban flooding risks in developing countries stem from a number of factors: impermeable surfaces that prevent water from being absorbed and cause rapid run-off; the general scarcity of parks and other green spaces to absorb such flows; rudimentary drainage systems that are often clogged by waste and which, in any case, are quickly overloaded with water; and the ill-advised development of marshlands and other natural buffers. When flooding occurs, faecal matter and other hazardous materials contaminate flood waters and spill into open wells, elevating the risks of water-borne, respiratory and skin diseases (Ahern et al., 2005; Kovats and Akhtar, 2008). The urban poor are often more exposed than others to these environmental hazards, because the only housing they can afford tends to be located in environmentally riskier areas, the housing itself affords less protection and their mobility is more constrained. The poor are likely to experience further indirect damage as a result of the loss of their homes, population displacement and the disruption of livelihoods and networks of social support (Hardoy and Pandiella, 2009).[5]

Kovats and Akhtar (2008, p. 169) detail some of the flood-related health risks: increases in cholera, cryptosporidiosis, typhoid fever and diarrhoeal diseases. They describe increases in cases of leptospirosis after the Mumbai floods of 2000, 2001 and 2005, but caution that the excess risks of this disease due to flooding are hard to quantify without better baseline data. They also note the problem of water contaminated by chemicals, heavy metals and other hazardous substances, especially for those who live near industrial areas.

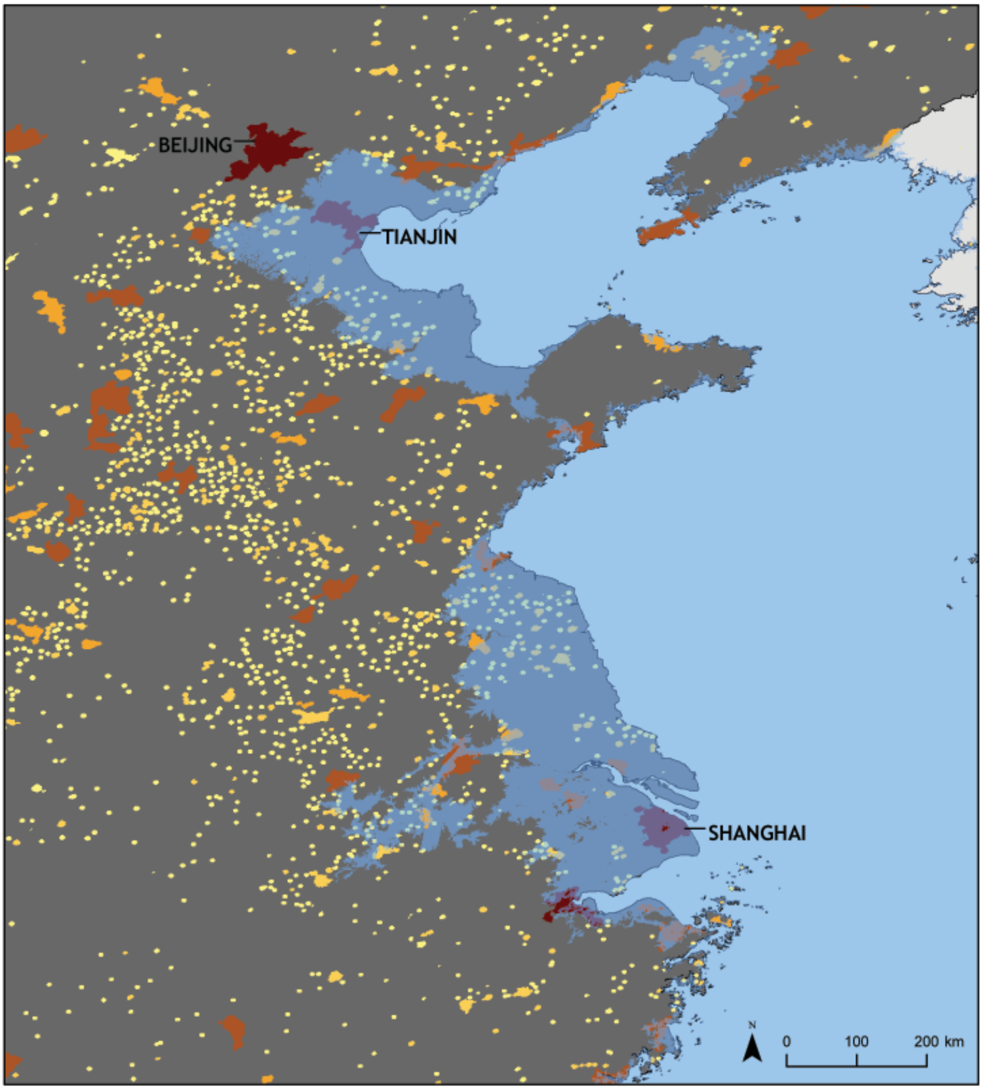
Figures 5.1–5.3 map the location of cities and large towns in relation to the low-elevation zone for several important metropolitan regions. Figure 5.1 presents a broad-scale overview of the the low-elevation zone of China near Beijing, Tianjin and Shanghai. This is a region in which China's extraordinarily successful growth strategy has perhaps overly concentrated population and production, without (it seems) due consideration of the upcoming environmental risks. Figure 5.2 shows how the low-elevation zone bisects Ho Chi Minh City in southern Viet Nam, and Figure 5.3 depicts the cities and towns in the low-lying coastal regions of Bangladesh.

Drylands

The principal characteristics of drylands are succinctly summarized by Safriel et al. (2005, p. 651) as follows: "Drylands are characterized by low, unpredictable, and erratic precipitation. The expected annual rainfall typically occurs in a limited number of intensive, highly erosive storms." Figure 5.4 depicts drylands ecosystems around the world. Safriel et al. (2005, p. 626) estimate that this ecosystem covers 41 per cent of the Earth's surface and provides a home to some 2 billion people. Developing countries account for about 72 per cent of the land area and some 87-93 per cent of the population of the drylands (the range depends on how the former Soviet republics are classified). McGrahanan et al. (2005) estimate that about 45 per cent of the population of this ecozone is urban.

Water shortages are already apparent in drylands ecosystems. There is an estimated 1,300 cubic metres of water available per person per year, well below the 2,000 cubic metre threshold considered sufficient for human well-being and sustainable development (Safriel et al., 2005, pp. 625, 632). Even for regions such as East Africa where climate scientists foresee increases in precipitation (Table 5.1), the rise in temperature is expected to cancel out the effects of greater rainfall, and, as a result, in some regions the frequency of rainy season failure will increase (Commission on Climate Change and Development, 2008). In the dryland areas where rivers are currently fed by glacier melt, the flows from this source will eventually decrease as the glaciers shrink, rendering flows in some rivers seasonal (Kovats and Akhtar, 2008). Cities dependent on these sources of water—such as in the Andes

Figure 5.1: Combined UN and GRUMP Urban Data for Beijing, Tianjin, Shanghai and Their Environs, China

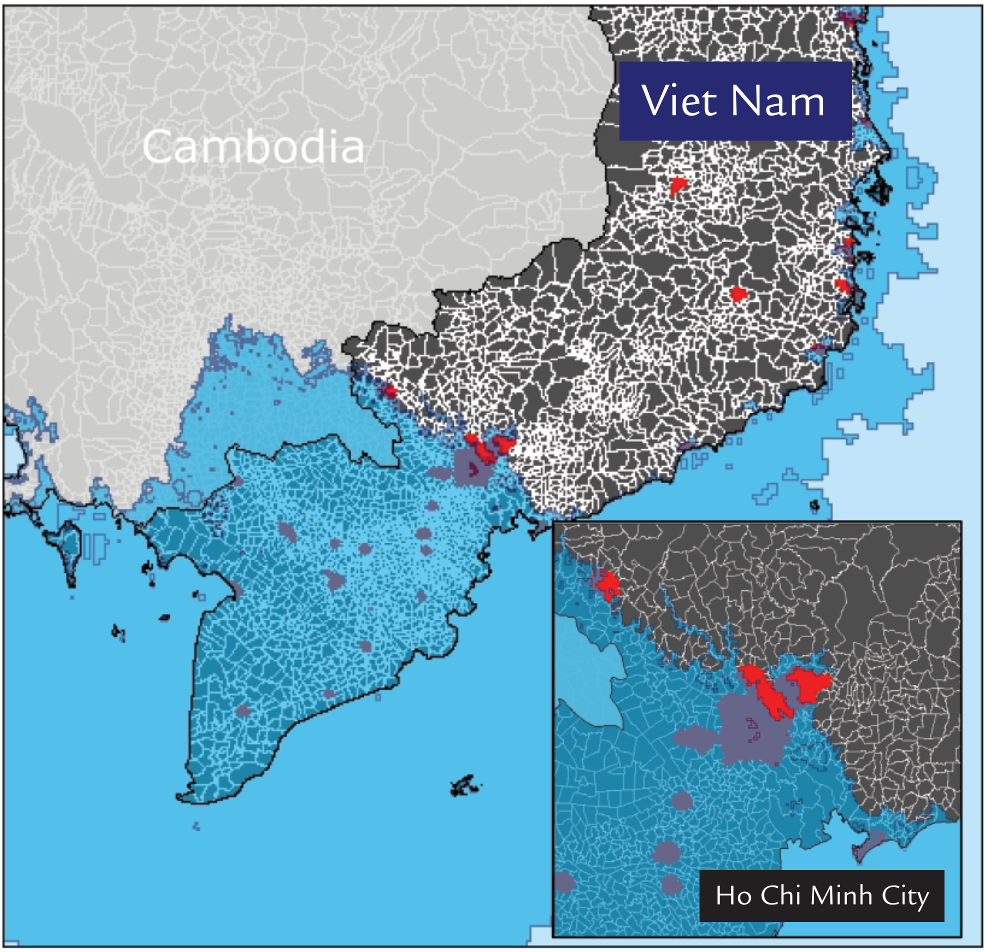


Note: Low-elevation coastal zone depicted in medium blue shading. Urban areas shown as points of light or patches of yellow or brown.
Source: McGranahan et al., 2007.

and in the areas fed by the Ganges and Brahmaputra Rivers—will eventually need to find alternatives.

Although many discussions of water stress leave the impression that increasing stress in drylands ecosystems already explains why so many of the urban poor find it difficult to secure access to water, the mechanisms by which this is posited to occur need scrutiny. McGranahan (2002) finds surprisingly little empirical evidence indicating that national water scarcity directly translates into a lack of access for the urban poor. Cross-national statistics, for instance, fail to confirm this common view: On the contrary, in a regression analysis of access to water for urban

Figure 5.2: Combined UN and GRUMP Urban Data for Southern Viet Nam



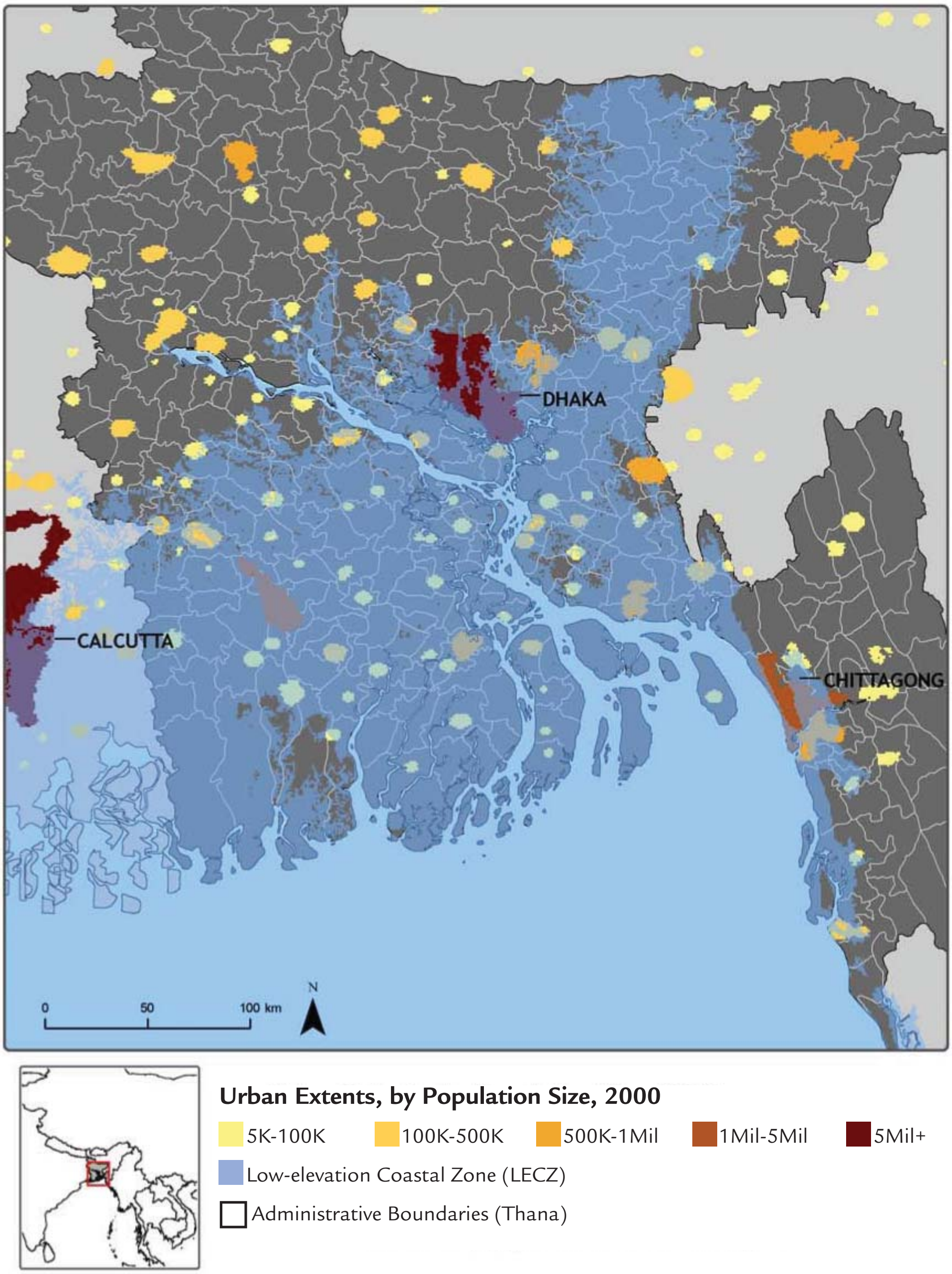
Note: Inset shows the low-elevation coastal zone intersecting Ho Chi Minh city. Low elevation coastal zone depicted in blue. Urban areas shown as points or patches of light shading. Detailed administrative boundaries indicated in light shading.

Data source: CIESIN, 2008.

(and rural) populations as a whole, with national income per capita included as an explanatory factor along with the per capita renewable freshwater resources available nationally, per capita income exhibited a strong positive association with access whereas the quantity of water resources available per capita displayed a weak and unexpectedly negative association. Evidence from more detailed, within-city case studies is also mixed. Summarizing, McGranahan (2002, p. 4) writes, "There is considerable case-specific evidence of cities with plentiful water resources where poor households do not have adequate access to affordable water, and cities with scarce water resources where poor households are comparatively well served."

Similarly, if in the future dryland cities increasingly turn to water conservation and demand management measures, it is far from obvious that this will automatically bring benefits to the urban poor. As McGranahan (2002, p. 4) cautions:

Figure 5.3: Combined UN and GRUMP Urban Data for Bangladesh



Note: *LECZ layer has been made semi-transparent to show the underlaying layers. Thus, the blue color is not uniform.*

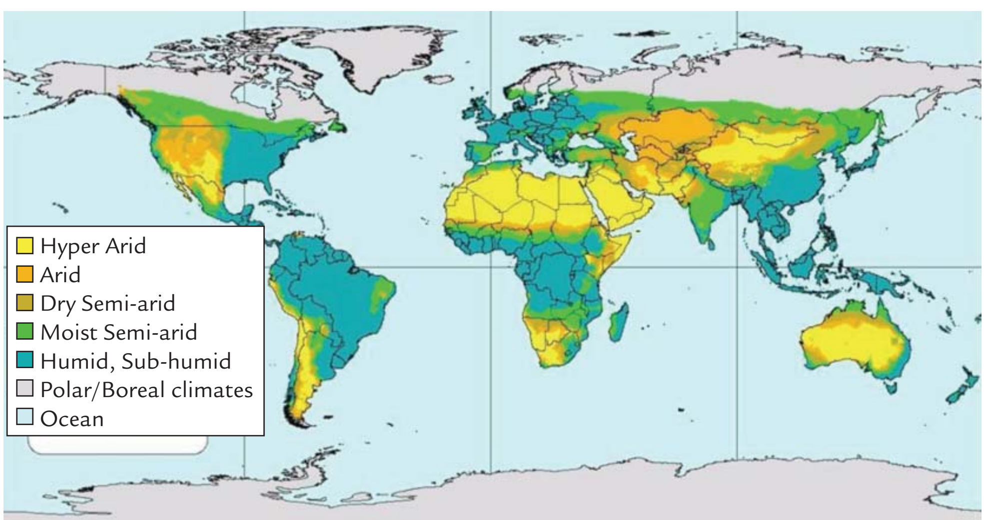
Note: Low-elevation coastal zone shown in medium blue shading. Urban areas shown as points or patches of light shading.
Data source: CIESIN, 2008.

It is often assumed that water saved in one part of an urban water system will be transferred to meet the basic needs of deprived residents in another part of the city (or town). . . . [But] first, even if demand management reduces supply problems within the piped water system, the households with the most serious water problems are typically unconnected, and getting them adequate water is likely to require infrastructural improvements. Second, the reason they are unconnected is likely to be because their needs are not economically or politically influential, and freeing up water within the piped water system is unlikely to change this. Third, if conservation is being promoted in response to water supply problems, then there are likely to be competing demands for the saved water, and quite possibly a need to reduce water withdrawals. In short, it is extremely unrealistic to assume that water saving measures will yield water for the currently deprived, unless this is made an explicit and effective part of a broader water strategy.

Thus, for example, if the governmental response to increasing water scarcity was to invest in a carefully regulated piped water system that reached all urban-dwellers, the most vulnerable residents could actually benefit. Alternatively, if the response involved placing greater restrictions on access to the existing piped water system, the most vulnerable residents would almost certainly suffer the most. However straight-forward the linkages between national water stress and the access of the urban poor may at first appear to be, there are multiple intervening social, political, economic and technical factors that complicate the situation and make it difficult to anticipate the consequences for the poor.

Water stress in drylands ecosystems has important implications that reach beyond access to drinking water. Especially in sub-Saharan Africa, a number of cities have become dependent on hydropower for much of their electricity (Showers,

Figure 5.4: The World's Drylands



Source: Commission on Climate Change and Development, 2008.

Table 5.1: Forecasts of Climate Change in Drylands Ecosystems

Region	Median projected temperature increase (°C)	Median projected precipitation increase (%)	Projected frequency of extreme warm years (%)	Projected frequency of extreme wet years (%)	Projected frequency of extreme dry years (%)
West Africa	3.3	+2	100	22	
East Africa	3.2	+7	100	30	1
Southern Sahara	3.4	-4	100	4	13
Southern Europe	3.6	-6	100		
Mediterranean	3.5	-12	100	46	
Central Asia	3.7	-3	100	12	
Southern Asia	3.3	+11	100	39	3

Source: Adapted from Commission on Climate Change and Development, 2008. See original for further notes and discussion of agreement among climate models.

2002; Muller, 2007). As Showers (2002, p. 639) described it, hydroelectric power is "a major source of electricity for 26 countries from the Sahel to southern Africa, and a secondary source for a further 13. . . . Hydroelectric dams are, however, vulnerable to drought when river flows are reduced. Cities and towns in countries from a wide range of climates were affected by drought induced power shortages in the 1980s and 1990s." Furthermore, "[i]n several nations urban areas receive electricity from hydropower dams beyond their national boundaries. . . . National drought emergencies, therefore, can have regional urban repercussions. Lomé and Cotonou suffered when interior Ghana's drought reduced power generation at the Akosombo Dam" (Showers 2002, p. 643).

Safriel et al. (2005) discuss other likely impacts of climate change in drylands ecosystems, including reductions in water quality and a higher frequency of dry spells that may drive farmers to make greater use of irrigation: "Since sea level rise induced by global warming will affect coastal drylands through salt-water intrusion into coastal groundwater, the reduced water quality in already overpumped aquifers will further impair primary production of irrigated croplands" (p. 650). The productivity consequences may have the effect of increasing the costs of production in agriculture, which may, in turn, cause prices to rise, reduce employment and earnings and possibly encourage both circular and longer-term migration to urban areas (Muller, 2007; Adamo and de Sherbinin, 2008).

New Data: Mapping Populations at Risk

Focusing on drylands and the low-elevation coastal zone, Table 5.2 shows the distribution of urban population by city-size ranges in Asia, and Table 5.3 expresses these data by showing the percentage of all Asian urban-dwellers in a given city-size range who live in these zones.[6] Tables 5.4 and 5.5 present the figures for Africa and South America. These tables show that drylands are home to about half of Africa's urban residents irrespective of city size and, in the important case of India, even greater percentages—ranging from 54 to 67 per cent. In South America and China, however, much lower percentages of all

Table 5.2: Distribution of the Asian Urban Population and Land Area in the LECZ and Drylands, by Population Size Ranges

City Population	Number of Cities	All Ecozones Population	All Ecozones Area	Drylands Population	Drylands Area	LECZ Population	LECZ Area
All Asia							
Under 100,000	10,582	341,000	446,295	142,000	219,204	27,200	28,753
100,000–500,000	1,470	301,000	279,866	122,000	141,552	37,000	26,061
500,000–1 million	180	124,000	94,797	48,500	46,348	15,700	8,689
1 million+	200	722,000	327,318	229,000	128,032	174,000	59,873
India							
Under 100,000	2,845	77,100	113,396	51,700	76,986	2,839	3,733
100,000–500,000	300	59,300	53,033	38,300	33,703	4,473	2,898
500,000–1 million	33	22,200	13,785	13,100	7,005	896	699
1 million+	37	126,000	41,800	68,500	24,355	29,400	4,321
China							
Under 100,000	5,711	198,000	167,796	58,000	54,829	15,700	11,040
100,000–500,000	690	141,000	81,895	40,300	30,713	15,300	6,803
500,000–1 million	81	56,400	29,438	13,100	9,502	8,406	3,164
1 million+	76	221,000	80,575	60,000	26,700	58,700	19,198
Asia Other Than India and China							
Under 100,000	2,026	65,900	165,102	32,300	87,389	8,661	13,980
100,000–500,000	480	100,700	144,938	43,400	77,137	17,227	16,361
500,000–1 million	66	45,400	51,574	22,300	29,841	6,398	4,827
1 million+	87	375,000	204,943	100,500	76,977	85,900	36,354

Note: Based on size and area in 2000, estimated using GRUMP methods.

urban-dwellers-live in drylands. For all of the regions considered here, significant numbers and percentages of urban residents live in the LECZ, although the figures are lower than for the drylands. Among all urbanites residing in cities of 1 million or more, the percentages in the LECZ range from 9.7 per cent in South America to 26.6 per cent in China.

Urban population density

The density of the urban population, especially in coastal areas, has important implications for the costs of climate-change adaptation, as well as for mitigation strategies to reduce emissions. Denser cities may (depending on many factors, including the quality of urban governance and management) economize on the use of scarce resources, including those of ecozones both within and near the city, and may produce fewer climate-damaging emissions. To a degree, density lowers the per-resident cost of providing water supply, drainage, sanitation and other infrastructure essential to urban adaptation. However, denser cities also present governments with health and management challenges, especially in large cities that lack adequate infrastructure (Dodman, 2008).

For a subset of data in which geographic units can be finely disaggregated (in terms of the number and geographic size of the city's administrative units)

Table 5.3: Percentages of the Asian Urban Population and Land Area in the LECZ and Drylands, by Population Size Ranges

City Population	Drylands		LECZ	
	Population	Area	Population	Area
All Asia				
Under 100,000	41.6	49.1	8.0	6.4
100,000–500,000	40.6	50.6	12.3	9.3
500,000–1 million	39.2	48.9	12.7	9.2
1 million+	31.7	39.1	24.1	18.3
India				
Under 100,000	67.1	67.9	3.7	3.3
100,000–500,000	64.5	63.6	7.5	5.5
500,000–1 million	59.1	50.8	4.0	5.1
1 million+	54.2	58.3	23.2	10.3
China				
Under 100,000	29.3	32.7	8.0	6.6
100,000–500,000	28.5	37.5	10.8	8.3
500,000–1 million	23.2	32.3	14.9	10.7
1 million+	27.2	33.1	26.6	23.8
Asia Other Than India and China				
Under 100,000	49.0	52.9	13.1	8.5
100,000–500,000	43.1	53.2	17.1	11.3
500,000–1 million	49.1	57.9	14.1	9.4
1 million+	26.8	37.6	22.9	17.7

Note: Based on size and area in 2000, estimated using GRUMP methods.

densities in the LECZ and the non-LECZ portions of the city can be compared. The GRUMP-based estimates indicate that population density is markedly higher in LECZ cities (Table 5.6). In Africa and Asia, LECZ cities, and the portions of such cities actually in the LECZ, exhibit substantially higher population densities. In South America, cities located (wholly or in part) in the LECZ are more densely populated than other cities, but, for cities that are only partly in the low-elevation zone, there is not much within-city difference in density evident between the LECZ and non-LECZ areas. The average density of these cities exceeds that of dryland cities and cities in other zones. Is the greater density of the LECZ due mainly to the presence of large cities in this zone? The bottom panel of Table 5.6 suggests otherwise. For cities both above and below 1 million persons, urban population density is greatest in the LECZ. Indeed, for cities having land outside the low-elevation zone, population densities in the non-LECZ areas are generally lower than densities in the zone.

Poverty: Looking Closer at Vulnerability

There is every reason to think that the urban poor are, and will continue to be, more vulnerable to climate change than other urban residents. The data needed to quantify such poverty-related vulnerabilities, however, are not yet available in

Table 5.4: Distribution and Percentages of the African Urban Population and Land Area in the LECZ and Drylands, by Population Size Ranges

City Population	Number of Cities	All Ecozones Population	All Ecozones Area	Drylands Population	Drylands Area	LECZ Population	LECZ Area
Under 100,000	3,247	61,800	123,359	29,800	67,017	3,820	5,042
100,000–500,000	301	61,400	58,417	27,800	28,854	6,870	4,695
500,000–1 million	32	22,100	13,050	10,700	7,107	3,531	1,788
1 million+	42	130,000	56,985	61,700	28,686	17,300	4,787

Percentage of Population and Land Area

City Population	Drylands Population	Drylands Area	LECZ Population	LECZ Area
Under 100,000	48.3	54.3	6.2	4.1
100,000–500,000	45.3	49.4	11.2	8.0
500,000–1 million	48.4	54.5	16.0	13.7
1 million+	47.5	50.3	13.3	8.4

Note: Based on size and area in 2000, estimated using GRUMP methods.

Table 5.5: Distribution and Percentages of the South American Urban Population and Land Area in the LECZ and Drylands, by Population Size Ranges

City Population	Number of Cities	All Ecozones Population	All Ecozones Area	Drylands Population	Drylands Area	LECZ Population	LECZ Area
Under 100,000	2,739	45,000	170,998	12,300	49,244	2,055	7,179
100,000–500,000	198	40,200	68,926	14,300	28,964	2,890	4,974
500,000–1 million	28	19,900	23,257	6,220	6,627	1,946	1,956
1 million+	34	111,000	71,677	25,500	20,234	10,800	5,844

Percentage of Population and Land Area

City Population	Drylands Population	Drylands Area	LECZ Population	LECZ Area
Under 100,000	27.4	28.8	4.6	4.2
100,000–500,000	35.6	42.0	7.2	7.2
500,000–1 million	31.2	28.5	9.8	8.4
1 million+	22.9	28.2	9.7	8.2

Note: Based on size and area in 2000, estimated using GRUMP methods.

a spatially-specific form on a global basis. To highlight the potential that would be inherent in such data, another large-scale, spatially-specific exercise is used: the World Bank's Small-Area Poverty Mapping project (Elbers et al., 2003, 2005; Muñiz, et al. 2008).

To set the stage, Figure 5.5 depicts the GRUMP data available for Medan, Indonesia's third largest city, located on the northern coast of Sumatra. The figure shows the low-elevation coastal zone in cross-hatching; underneath can be seen the administrative units whose population sizes are indicated by shading

Table 5.6: City Population Density in Persons per Square Kilometre, by Ecozone and City Population Size Ranges, All Regions, Medan, Indonesia

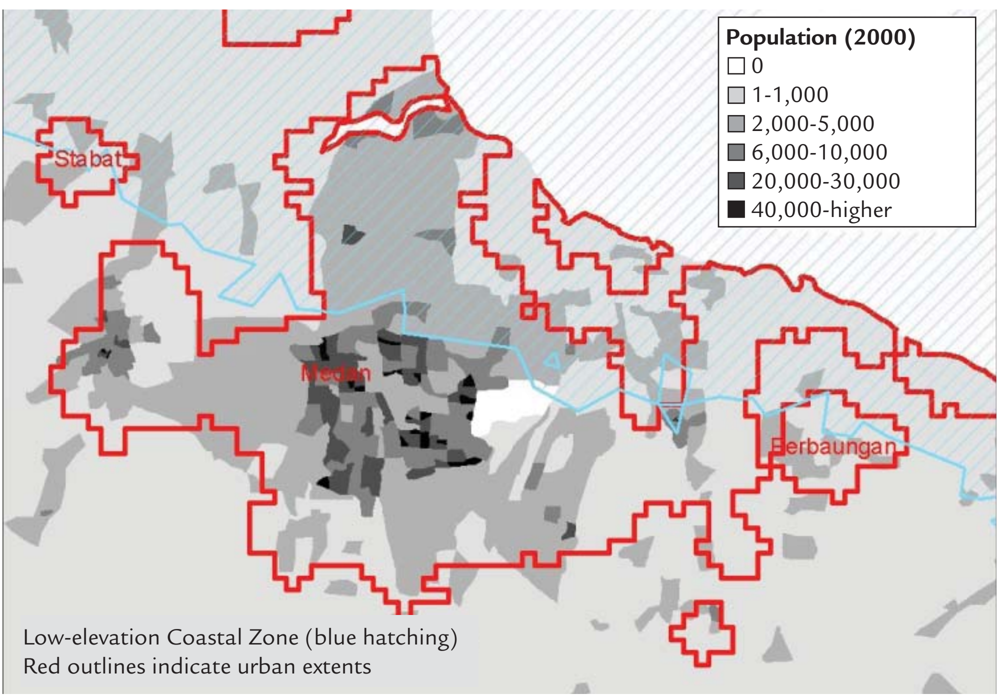
Region	Cities Outside LECZ Density	Cities Fully or Partly in LECZ	
		LECZ Density	Other Density
Africa	620	2,406	1,680
Asia	1,473	1,827	1,525
South America	661	1,079	1,003

Region	Cities Under 1 Million			Cities Over 1 Million		
	Cities Outside LECZ Density	Cities Fully or Partly in LECZ		Cities Outside LECZ Density	Cities Fully or Partly in LECZ	
		LECZ Density	Other Density		LECZ Density	Other Density
Africa	542	1,274	872	2,705	4,294	2,960
Asia	1,313	1,463	1,136	2,413	3,518	3,125
South America	560	805	678	1,251	1,665	1,676

Note: Figures are for cities that intersect more than one administrative area; cities contained within a single administrative area are omitted.

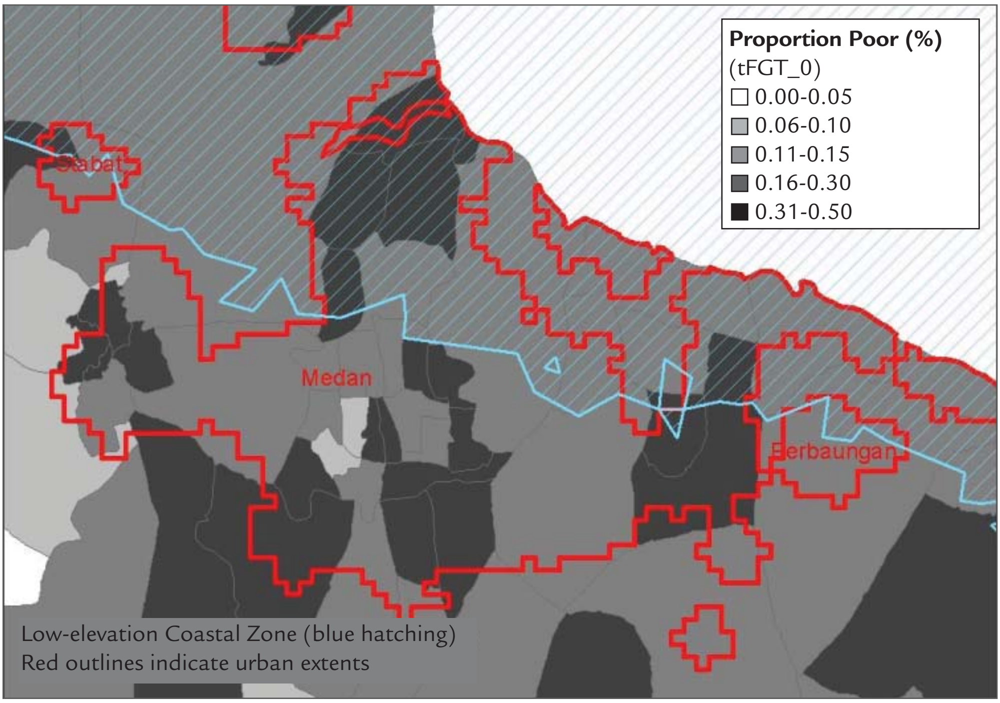
(darker shades represent larger populations). The outlined areas are the GRUMP urban extents as identified through satellite imagery. This assemblage of data gives a detailed picture of the population exposed to coastal risks, but it does not distinguish residents according to their levels of income, an important factor in

Figure 5.5: Population exposed in the LECZ: Medan, Indonesia (Total population of each administrative area)



Source: Columbia University's Global Rural–Urban Mapping Project.

Figure 5.6: Vulnerability and the LECZ: Proportion Poor in Each Administrative Area, Medan, Indonesia



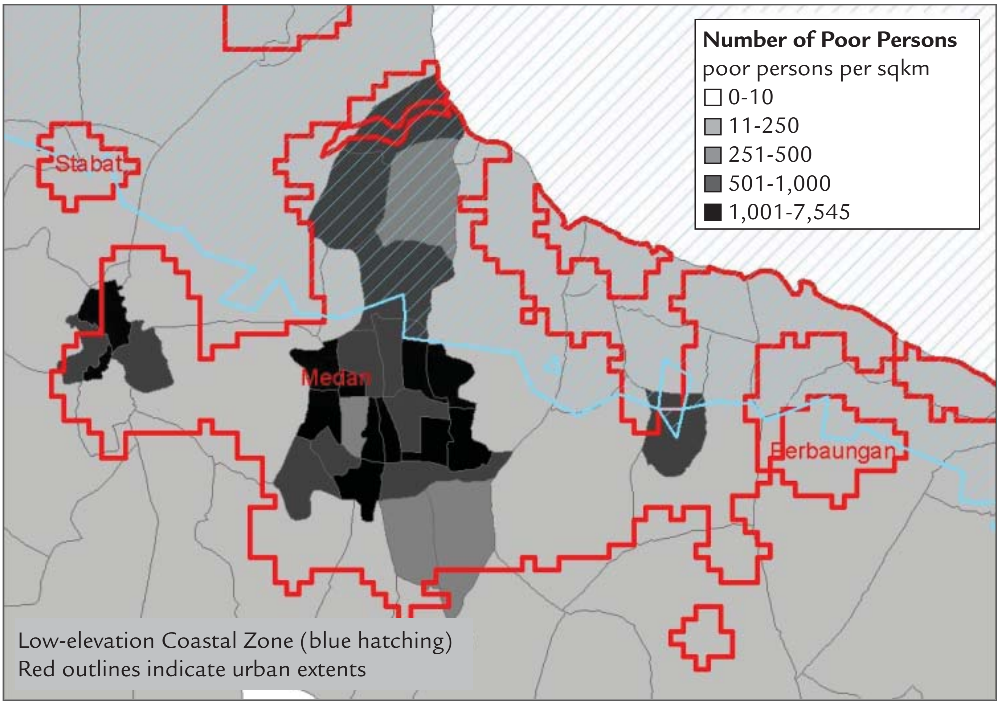
Source: GRUMP and the World Bank's Small-Area Poverty Mapping Project.

determining whether they have sufficient resources (e.g., housing well-enough constructed to withstand at least moderate flooding and storm surges) to fend off climate-related risks.

To shed light on the issue of vulnerability, Figure 5.6 draws the poverty data into the picture. Shown here (in the shading of the administrative areas) is the proportion of Medan's residents who live below the all-Indonesia poverty line.[7] Darker colours indicate higher proportions of the poor. Maps such as this can provide useful guidance to policymakers and planners needing to make decisions about where to allocate scarce urban adaptation resources and intervention efforts. Figure 5.7 presents an alternative view, depicting the total numbers of urban poor exposed to risk, which may be the more salient aspect of vulnerability for disaster preparedness and response agencies, non-governmental organizations and planners.

For countries whose administrative data are finely-enough disaggregated, it is possible to explore whether there is greater poverty in the low-elevation zones than outside them. As with the population density calculations given above, the percentage and number of poor urban-dwellers in the LECZ portion of cities having any land in that zone are estimated, making comparisons with poverty in the portions of the city lying outside the zone, as well as with poverty rates and counts in cities situated outside the LECZ altogether. Table 5.7 presents the results for the seven countries providing spatial data at a resolution high enough to support intra-urban analysis: Cambodia, Ecuador, Honduras, Indonesia, Panama, South Africa and Viet Nam.[8]

Figure 5.7: Vulnerability and the LECZ: Number of Poor in Each Administrative Area, Medan, Indonesia



Source: GRUMP and the World Bank's Small-Area Poverty Mapping Project.

No single message emerges from this analysis; rather, what is striking is the heterogeneity across countries in the association between poverty and the LECZ. In Viet Nam, for example, more than 2 million poor city-dwellers live in the LECZ, and poverty rates are highest in the LECZ portion of these cities. In the Vietnamese cities with any LECZ land, 28 per cent of the LECZ population is poor compared to 20 per cent of the non-LECZ population. However, the poverty rate in the non-LECZ cities is similar to that of the LECZ portion of the LECZ cities, although the non-LECZ cities do not hold nearly as many poor residents in total. The situation is quite different in Honduras and South Africa, where the highest rates of urban poverty (and the greatest numbers of poor) are found outside the coastal zone. In Indonesia, however, the proportion of the poor differs little according to LECZ, with 3.2 million urban poor living in the LECZ and another 4.5 million in the non-LECZ portion of the LECZ cities. To judge from the seven countries in this small sample, the LECZ is not, with any consistency, home to more of the urban poor. Nor do its administrative units tend to have higher poverty percentages. It is clear that estimates of vulnerability couched in terms of percentages of the poor population must be supplemented with estimates of the total number of poor people. These are very different metrics, and, if the examples explored here are any guide, they are likely to lead to different priority rankings for targeting interventions.

Forecasting City Population Growth

This chapter has shown how urban settlements are currently distributed according to ecological zone, but will these patterns be substantially reshaped as cities and towns continue to grow? To generate forecasts of city population growth, the city time-series supplied by the United Nations can be used. Ideally the forecasting exercise would also project changes in the spatial extent of cities; unfortunately, scientifically defensible estimates of spatial change are not yet available for a sufficiently large sample of cities. (As the Landsat archives come fully into the public domain, possibilities for a large-scale analysis of spatial growth will emerge.) Where population growth is concerned, however, the elements are on hand for a detailed analysis. Some illustrative results are presented here.

Estimated regression models of city population growth rates from 1950–2007 have been developed for cities in Africa, Asia and South America. This analysis is based on the United Nations Population Division's longitudinal database of city population, which has been assembled mainly for cities with populations of 100,000 and above. Because the spatial extent of cities can be defined in different ways—in terms of the city proper, the urban agglomeration or even metropolitan regions— and the definition adopted in the data can change from one point in time to the next even for a given city, controls for city definitions must be introduced in this analysis. The important role of fertility as a driver of city population growth must also be recognized, and, in this analysis, use is made of the United Nations estimates of national fertility (the national total fertility rate, or TFR), as well as its estimates of child mortality (Q5, the proportion of children dying before their fifth birthday). The specification also reserves a place for otherwise unmeasured, city- specific features, which are embedded in a time-invariant random or fixed effect in the regression's disturbance term. The influence of the ecozone on city growth can be estimated in the ordinary least squares (OLS) and random-effects models, but because ecozone is a time-invariant feature, its influence on city growth cannot be estimated using fixed-effect modelling techniques.

Tables 5.8–5.11 present the results from one such modelling exercise, first for all cities pooled across regions, and then separately for cities in each of the three regions. Some important results are common to all three regions. In particular, fertility rates display a strong positive effect on city growth rates irrespective of region, with the coefficients for South America being the largest. Even in Africa, however, the fertility coefficients suggest that a 1-child drop in the total fertility rate is associated with a decline of 0.395–0.490 percentage points in city population growth rates. This is a quantitatively important effect. Child mortality rates show the expected negative sign in the pooled results in the regions of Asia and South America, but not in Africa. Across regions, larger cities tend to grow more slowly than do cities with populations under 100,000 (the omitted category in the regression specification). Controls for changes in the statistical concept for which city population is recorded—city proper, agglomeration, etc. (including whether the concept was unknown)—make a statistically significant difference as a group (results not shown), but the details are complicated.

Table 5.7: Estimates of Poverty for Selected Countries, for Cities Located in and Outside the Low-elevation Coastal Zone, Various Years

		Percentage Poor		
		Cities Outside LECZ	Cities Fully or Partly in LECZ	
Country	Year	All Residents	LECZ Residents	Others
Cambodia	1998	31.36%	36.67%	33.50%
Ecuador	2001	55.57%	50.44%	50.06%
Honduras	2001	78.29%	70.21%	70.02%
Indonesia	2000	23.23%	21.96%	22.01%
Panama	2000	46.53%	46.20%	45.01%
South Africa	1996	45.19%	17.16%	18.65%
Viet Nam	1999	27.60%	27.97%	20.32%

Where ecozones are concerned, some differences emerge by region along the lines suggested earlier. In Asia, city growth in the LECZ is significantly faster than in the benchmark zone (other coastal), but no significant effect can be detected in either Africa or South America. City growth in the drylands ecosystem is insignificantly different from the benchmark zone in all three regions. At least for these two important ecozones, therefore, there is nothing in the results to indicate that, outside Asia, cities in climate-sensitive locations tend to grow faster than elsewhere. The LECZ result for Asia is therefore something of a special case, albeit for a region whose total urban population is enormous.

Figure 5.8 summarizes the forecasts of city population growth rates in Asia, distinguishing between cities situated in the LECZ and those outside this zone. The median growth forecast is shown, accompanied by the upper and lower quartiles (using the results of the random-effects regression). Although the population growth rates of LECZ cities in Asia are initially somewhat higher than those of non-LECZ cities, both types of cities are projected to experience slower growth in the future—mainly due to projected lower fertility rates, which the regressions demonstrate are powerful, if often-overlooked, influences on city growth rates. Eventually, according to these forecasts, a convergence is to be anticipated between the LECZ and non-LECZ city growth rates in this region of the developing world.

Conclusions

The precision of climate science data and models continues to improve, and more detailed estimates are becoming available on the spatial distribution of climate-related hazards. At the moment, however, far less data-gathering and modelling are underway in the social sciences to document exposure and vulnerability on a spatially-specific basis.[9] This chapter has taken a modest step toward assembling the requisite population and socio-economic data. Using recently mapped information on the populations of cities and towns in Africa, Asia and Latin America,

Number of Poor			Number of 1 km cells observed		
Cities Outside LECZ	Cities Fully or Partly in LECZ		Cities Outside LECZ	Cities Fully or Partly in LECZ	
All Residents	LECZ Residents	Others	All Residents	LECZ Residents	Others
128,347	29,540	107,999	36	13	9
1,277,348	291,947	361,388	73	35	33
642,154	28,859	41,404	71	14	13
4,810,857	3,240,764	4,535,325	403	299	229
41,516	38,420	283,851	30	17	16
2,555,721	59,730	1,037,184	622	29	28
342,030	2,112,987	413,623	79	131	36

Table 5.8: City Population Growth Rate Regressions, Pooled Results for Africa, Asia and South America

	OLS	Random-Effects	Fixed-Effects
National TFR	0.652	0.685	0.775
	(19.80)	(19.83)	(15.61)
National Q5	-0.005	-0.006	-0.011
	(-6.68)	(-7.73)	(-9.47)
Cultivated	0.166	0.218	
	(1.31)	(1.53)	
Dryland	-0.294	-0.290	
	(-4.36)	(-3.71)	
Forest	0.073	0.056	
	(0.99)	(0.66)	
InlandWater	0.400	0.426	
	(5.90)	(5.45)	
Mountain	0.310	0.315	
	(4.60)	(4.06)	
LECZ	0.128	0.090	
	(1.75)	(1.05)	
100,000 – 500,000	-0.901	-0.982	-1.614
	(-11.58)	(-12.11)	(-13.89)
500,000 – 1 million	-1.085	-1.360	-3.115
	(-7.37)	(-8.86)	(-13.76)
Over 1 million	-1.453	-1.723	-4.060
	(-9.13)	(-9.79)	(-13.08)
Constant	1.412	1.437	2.667
	(6.58)	(6.04)	(9.27)
σu	0.978		
	(21.09)		
σe	3.035		
	(128.14)		

Note: Z-statistics in parentheses. Controls for city definition included, but coefficients are not shown.

Table 5.9: City Population Growth Rate Regressions for Africa

	OLS	Random-Effects	Fixed-Effects
National TFR	0.490	0.490	0.395
	(5.80)	(5.83)	(3.40)
National Q5	0.004	0.004	0.003
	(2.27)	(2.28)	(1.00)
Cultivated	0.446	0.446	
	(2.04)	(2.05)	
Dryland	-0.294	-0.294	
	(-1.68)	(-1.69)	
Forest	-0.133	-0.133	
	(-0.76)	(-0.77)	
InlandWater	0.530	0.530	
	(3.34)	(3.35)	
Mountain	0.549	0.549	
	(3.19)	(3.20)	
LECZ	0.059	0.059	
	(0.32)	(0.32)	
100,000 - 500,000	-1.065	-1.065	-1.905
	(-4.94)	(-4.96)	(-5.76)
500,000 - 1 million	-1.698	-1.698	-4.052
	(-3.26)	(-3.28)	(-5.69)
Over 1 million	-2.644	-2.644	-6.254
	(-4.40)	(-4.42)	(-6.45)
Constant	1.421	1.421	3.213
	(2.40)	(2.41)	(3.78)
σu	0.000		
	(.)		
σe	3.964		
	(74.40)		

Note: Z-statistics in parentheses. Controls for city definition included, but coefficients are not shown.

simple maps have been compiled of urban settlements in both the low-elevation coastal zone and the drylands of these world regions. The climate and bio-physical sciences suggest that the hazards expected to materialize in these zones will be substantially different; and, as has been seen in the demographic analysis presented in this chapter, the settlement patterns in these zones are also quite different.

In the low-elevation zone, exposure to flooding and other extreme weather events will depend not only on the settlement patterns that are evident today, but also on how urban populations and their arrangement across risk zones change in the future. In Asia, where a large share of the world's urban population growth is currently taking place, the cities in the low-elevation zone have grown faster to date than have those outside the zone. To explore the longer-term prospects, preliminary city population growth forecasts have been presented which suggest that rates of city growth are likely to decline as fertility rates decline, indicating that cities in the LECZ will eventually come to grow at about the same rates as elsewhere. Of course, the data and methods used to produce such forecasts need to be developed in much more depth. In particular, a way will need to be found to adjust the forecasts to incorporate migration, which is largely induced by spatial differences

Table 5.10: City Population Growth Rate Regression Results for Asia

	OLS	Random-Effects	Fixed-Effects
Over 1 million	-2.644	-2.644	-6.254
National TFR	0.601	0.650	0.929
	(14.09)	(14.44)	(13.68)
National Q5	-0.008	-0.009	-0.019
	(-8.32)	(-9.15)	(-12.76)
Cultivated	-0.303	-0.223	
	(-1.40)	(-0.92)	
Dryland	0.055	0.040	
	(0.59)	(0.38)	
Forest	-0.057	-0.013	
	(-0.63)	(-0.13)	
InlandWater	0.473	0.491	
	(5.38)	(4.96)	
Mountain	0.392	0.345	
	(4.59)	(3.59)	
LECZ	0.303	0.263	
	(3.16)	(2.42)	
100,000 - 500,000	-0.858	-0.927	-1.540
	(-9.04)	(-9.39)	(-10.62)
500,000 - 1 million	-1.137	-1.359	-3.029
	(-6.89)	(-7.87)	(-11.33)
Over 1 million	-1.481	-1.680	-3.780
	(-8.39)	(-8.66)	(-10.28)
Constant	2.097	2.041	2.689
	(6.72)	(5.96)	(7.33)
σu	0.814		
	(12.80)		
σe	2.849		
	(95.40)		

Note: Z-statistics in parentheses. Controls for city definition included, but coefficients are not shown.

in real standards of living. Historically, the lower transport costs of trade provided by the LECZ have proven to be a powerful force attracting migrant labour and capital. In China and elsewhere, it remains to be seen whether climate change will introduce risks that offset the economic logic that has driven coastal development for millennia. Here, as elsewhere, the adaptation policies and investments adopted by national and local governments will have a key role in shaping urban growth.

In drylands, climate change will be manifested in complex ways, but it seems probable that, in many places, the net effect will be to increase water stress. The consequences are difficult to foresee, and, as with coastal settlement, will depend in part on how people and their governments respond to scarcity. The drylands occupy substantially more land overall than the LECZ, and, although population densities are generally lower, a larger share of urban-dwellers live in drylands than in the low-elevation zone. There is also considerable variation in the dryland shares according to region. Preliminary city growth estimates indicate that, in Africa, Asia and Latin America, dryland city populations are growing neither significantly faster nor significantly slower than in other zones. This finding, however, will need to be revisited as data and methods improve.

Table 5.11: City Population Growth Rate Regressions for South America

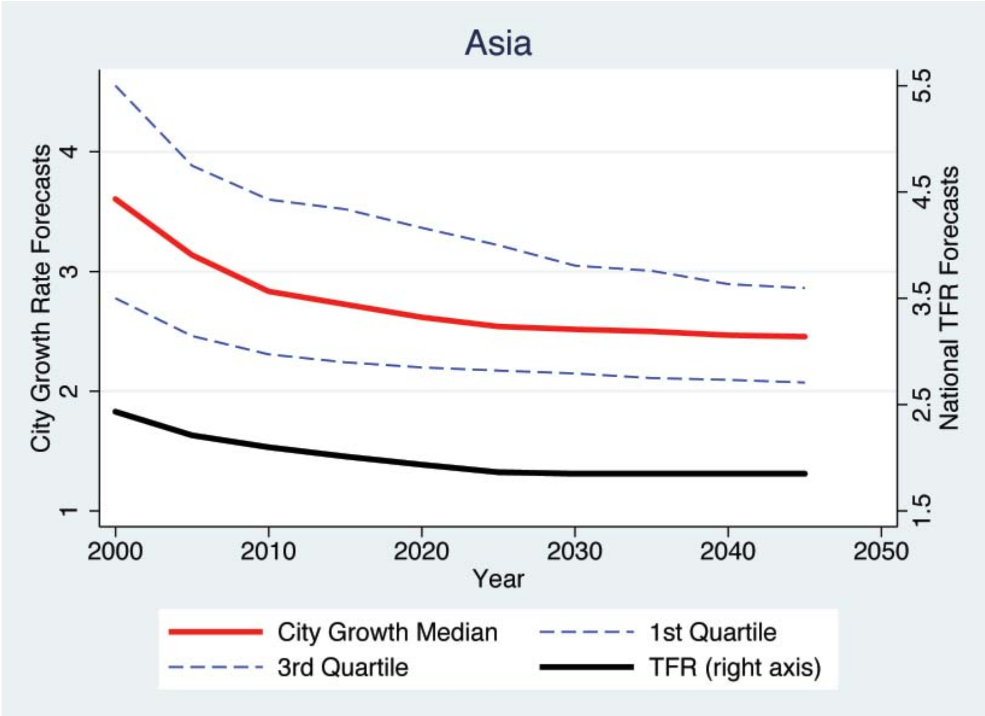
	OLS	Random-Effects	Fixed-Effects
National TFR	0.853	0.964	1.118
	(9.32)	(9.88)	(9.42)
National Q5	-0.002	-0.005	-0.012
	(-0.56)	(-1.67)	(-2.94)
Cultivated	0.189	0.242	
	(0.72)	(0.62)	
Dryland	-0.025	-0.087	
	(-0.20)	(-0.46)	
Forest	0.142	0.148	
	(0.78)	(0.52)	
InlandWater	0.294	0.328	
	(2.59)	(1.86)	
Mountain	-0.232	-0.255	
	(-2.07)	(-1.48)	
LECZ	-0.167	-0.181	
	(-1.32)	(-0.93)	
100,000 - 500,000	-0.800	-0.897	-1.091
	(-6.33)	(-6.95)	(-7.15)
500,000 - 1 million	-0.785	-1.061	-1.588
	(-2.83)	(-3.78)	(-4.69)
Over 1 million	-1.193	-1.348	-1.964
	(-3.91)	(-3.83)	(-4.13)
Constant	0.773	0.723	1.454
	(2.16)	(1.50)	(4.07)
σu	1.224		
	(17.01)		
σe	1.833		
	(53.46)		

Note: Z-statistics in parentheses. Controls for city definition included, but coefficients are not shown.

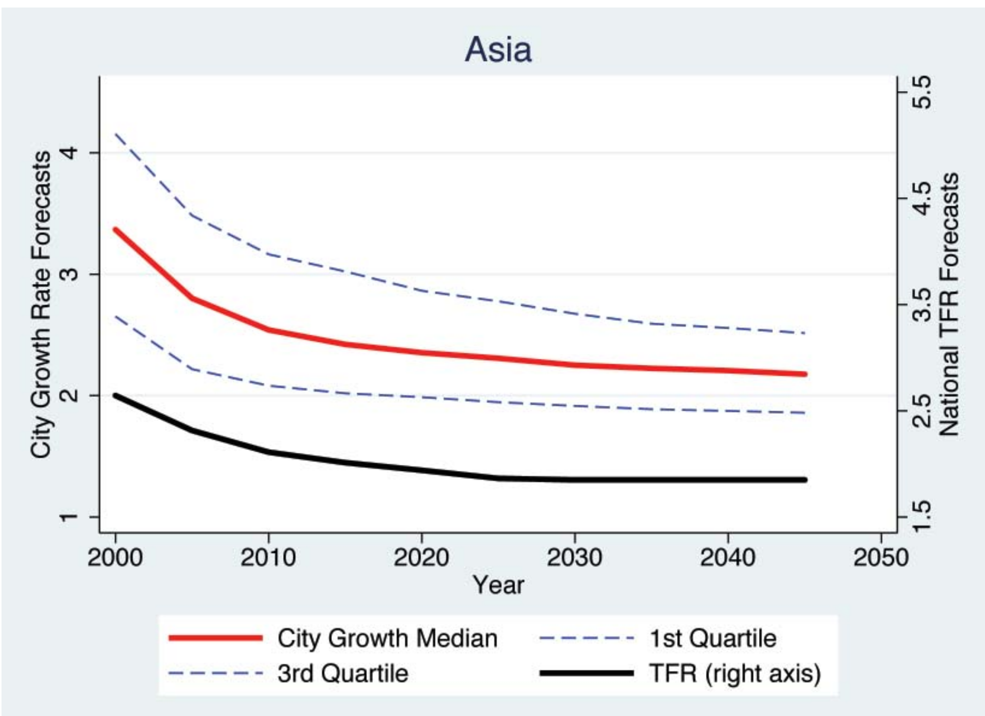
If urban climate adaptation plans are to be effective, they will need to be informed by evidence that is spatially-specific, whether on the populations exposed to risk or on the spatial patterns of these risks. As climate change approaches, more must be learned about the demographic and socio-economic characteristics of the urban and rural populations who will be affected by it, with migration behaviour, age and educational distributions, the quality and durability of housing and measures of poverty all being of high priority. The 2010 round of national censuses will shortly be fielded, and the opportunity must be seized to process these census data and map them in the fine spatial and jurisdictional detail needed for adaptation planning. To be sure, there are technical difficulties in putting census data into a geographic information system; in some countries, no doubt, disagreements over jurisdictional boundaries will need resolution. But once the spatial frame is established, it will provide an organizing framework for all manner of demographic, economic, social and physical data. Maps compel attention: They give national and local authorities and researchers a familiar place to start in documenting vulnerabilities at the finely disaggregated spatial scales needed

Figure 5.8: Forecasts of City Population Growth Rates in Asia

LECZ Growth Forecasts:



Non-LECZ Forecasts:



for effective intervention; and they can be expected to invigorate thinking about climate change at the local, regional and national levels, providing poor countries with a voice in the global conversation on climate change adaptation.

Notes

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2 The authors are in the process of adding migration data from these surveys and other sources. The challenges of integrating satellite with such population data are discussed in Chapter 13.

3 See: Douglas et al., 2008, and Awuor et al., 2008.

4 See: Hardoy and Pandiella, 2009.

5 For further discussion of urban exposure and vulnerabilities, see: Campbell-Lendrum and Woodruff (2006); UNDP (2004); Campbell-Lendrum and Corvalán (2007).

6 The tables are based on GRUMP estimates of the population of urban agglomerations circa 2000; they report the number of such agglomerations that are detected via the night-time lights. Note that the LECZ and drylands are not mutually exclusive; a given city can be located in both zones.

7 An urban poverty line would be preferable, in that urban poverty lines (sometimes) take into account urban-specific costs of living that are not considered in the national poverty lines. See: Montgomery et al., 2003, and Muñiz et al., 2008.

8 Of the poverty mapping efforts conducted in over fifty countries, fewer than half have been made available as spatially-coded datasets (Muñiz et al., 2008).

9 For more on the data issues involved, see Chapter 13.

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6

Crisis or Adaptation? Migration and Climate Change in a Context of High Mobility

Cecilia Tacoli

Introduction

The impact of climate change on population distribution and mobility is attracting growing interest and fuelling heated debate. Figures that are frequently cited estimate that, by 2050, the number of people forced to move primarily because of climate change will range between 200 million and 1 billion.[1] Underlying these predictions is the view that migration reflects a failure to adapt to changes in the physical environment and that migrants are a relatively undifferentiated group all making similar emergency responses and moving to random destinations, including international ones. This is somehow at odds with the more nuanced view of migration as a key adaptive response to socio-economic, cultural and environmental change. From this perspective, the specific characteristics of migrant flows—duration, destination and composition—are essential to understanding their impact on sending and destination areas and to developing appropriate policies.

It is likely that both extreme weather events (storms, floods, heat waves) and changes in mean temperatures, precipitation and sea levels will in many cases contribute to increasing levels of mobility. However, there are inherent difficulties in predicting with any precision how climate change will impact on population distribution and movement. This is partly because of the relatively high level of uncertainty about the specific effects of climate change, and partly because of the lack of comprehensive data on migration flows, especially movements within national boundaries, in particular, for low-income countries that are likely to be most affected by climate change (Kniveton et al., 2008). Better information is important to formulate appropriate policy responses at the global level and at the local and national levels.

At the same time, policies that build on existing strategies to support adaptation to climate change are among the most likely to succeed. There is growing evidence suggesting that mobility, along with income diversification, is an important strategy to reduce vulnerability to environmental and non-environmental risks, including economic shocks and social marginalization. In many cases, mobility not only increases resilience but also enables individuals and households to accumulate assets. As such, it will probably play an increasingly crucial role in adaptation to climate change. Policies that support and accommodate mobility and migration are important for both adaptation and the achievement of broader development goals. However, in most cases, migration is still seen by many government and international agency staff as disruptive and requiring control and restrictive measures. The key argument of this chapter is that what is needed urgently is a radical change in perceptions of migration, as well as a better understanding of the role that local and national institutions need to play in making mobility a part of the solution rather than the problem.

The Context: Policymakers' Perceptions of Migration

There is a real risk that alarmist predictions of climate-change-induced migration will result in inappropriate policies that will do little to protect the rights of those most vulnerable to climate change (GECHS, 2008; Piguet, 2008). This is not surprising: As noted, migration is generally perceived as problematic, and most policies try to influence the volume, direction and types of movement rather than accommodate flows and support migrants.

Environmental factors affect patterns of migration and mobility within a broader context of important changes in population distribution. Perhaps the most widely acknowledged transformation is urbanization: It is estimated that, since 2008, half of the world's population is estimated to live in urban centres, and over 90 per cent of the world's population growth in the coming decades is expected to be in urban areas (United Nations, 2008b). This, of course, does not mean that all regions have similar levels or rates of urbanization. Moreover, while there is a strong statistical association between urbanization and economic growth,[2] the scale of urban poverty in many low-income countries is growing rapidly; in many middle-income nations, the rate now exceeds rural poverty (Tacoli et al., 2008).

Rural-urban migration is often held responsible for the growth of urban populations and urban poverty. There is, however, little evidence to support such claims. According to available United Nations estimates, in the majority of the world's countries, natural population increase (the net excess of births over deaths in urban areas) makes a larger contribution than the combined effects of rural-urban migration and reclassification of settlements from rural to urban (United Nations, 2008a).[3] Moreover, in most countries, rural migrants are not the majority of the urban poor (Montgomery et al., 2004), nor are they the only residents of low-income informal settlements (Tacoli et al., 2008). In addition, nations with the largest contributions of rural-to-urban migration to urban population growth are often the wealthiest or those with the most rapid economic growth.

Nevertheless, for most governments in low- and middle-income nations, migration has become a key policy issue and is perceived as a growing problem. A review of Poverty Reduction Strategy Papers of countries across Africa shows the depth of negative perceptions of migration, which is seen as putting pressure on urban areas, promoting the spread of crime and HIV/AIDS, stimulating land degradation and contributing to both urban and rural poverty (Black et al., 2006).

Between 1996 and 2003, the proportion of governments in low- and middle-income countries that implemented policies to influence internal migration grew from 51 to 73 per cent (United Nations, 2004). Most of these measures have had little success, however, and have often resulted in increasing hardships for the urban poor (UNFPA, 2007; United Nations, 2008a). They also overlooked the fact that most migrants do better than those who remain in rural areas and that their remittances are an important component of the budgets of rural households. Plans intended to tackle the possible impacts of climate change on population distribution need to take into account a policy context that does not generally recognize or support the positive potential of migration.

Despite the importance of urbanization, it is misleading to assume that rural-urban migration is the predominant direction of movement within countries. To a large extent, the direction of migration flows reflects a country's level of urbanization (the proportion of its population residing in areas classified as urban) and the nature of its economic base. Rural-rural migration is prevalent in agriculture-based economies, such as in many low-income African nations, while urban-urban movement is more important in regions with high levels of urbanization, such as much of Latin America and the Caribbean. Rural-urban migration tends to be high in areas with high levels of economic growth and expanding industry and service sectors, but even in countries such as India and Viet Nam, rural-rural migration flows are also large. In Viet Nam, 37 per cent of the migration captured by the 1999 census was among rural areas, compared to 26 per cent among urban centres, 10 per cent from urban to rural areas and 27 per cent rural to urban. In India, 38 per cent of recent migrants were estimated to move among rural areas (Skeldon, 2003). Rural-rural migration tends to be dominated by the poorest groups, who often do not have the skills, financial capital or social networks to move to urban centres.

It is also misleading to assume that migration from poor to rich countries is the predominant form of movement. International migration only accounts for a small proportion of all movement and much of it is within regions rather than towards high-income countries. At the global level, however, it is often assumed that climate-change-related migration will be across borders, and from poor to rich countries. Given the contradictory stances toward international migration in destination countries—where the acknowledged need for migrant labour often goes hand in hand with attempts to curtail arrivals, especially from low-income countries—it is not surprising that the prospect of millions of climate refugees landing on the shores of rich countries is seen with alarm. In March 2008, the European Union High Representative for foreign and security policy, Javier Solana, warned that "such migration may increase conflict in transit and destination areas. Europe must expect substantially increased migratory pressure" (Solana, 2008).

Climate Change Migrants: The Debate and the Evidence

The relationship between climate change and migration has been rightly defined as "complex and unpredictable" (Brown, 2008), and the scarcity of reliable evidence on the topic has contributed to the heated and highly politicized discussion on the potential existence of environmental refugees, as well as predictions on their numbers. The term 'environmental refugee'—people forced to move because of environmental degradation resulting from climate change—was first formally used in the 1970s and was heavily influenced by the neo-Malthusian assumption that population growth would lead to migration and conflict caused by resource scarcity. Such views were not supported by evidence, and environmental pressure as a fundamental cause of migration was generally downplayed until recently, when increased attention to the impacts of climate change refuelled the debate (Massey et al., 2007; Morrissey, 2009; Zolberg, 2001).

The most frequently cited figure predicts that, by 2050, there could be as many as 200 million environmental refugees (Myers, 2005; Stern Review Team, 2006). It is surprising that this has become an unquestioned orthodoxy, especially among natural scientists concerned with climate change, in view of the widespread criticisms of both the figure and its conceptual underpinnings, and perhaps even more so given the growing consensus on the importance of multiple and overlapping causes of most migration flows, including economic, social and political factors (Castles, 2002; GECHS, 2008; Hugo, 2008; Morrissey, 2009; Piguet, 2008). This recognition is reflected in the changing focus of the reports of the Intergovernmental Panel on Climate Change (IPCC) from an earlier emphasis on human migration to the current stress on population vulnerability and capacities to adapt to climate change (Raleigh et al., 2008).

The key problem with the concept of environmental refugees is the implicit assumption that there is a direct causal link between environmental change and migration. The figure proposed is an estimate of the numbers of people at risk—that is, of the populations living in areas most likely to be affected by the negative impacts of climate change—rather than the number of people who are in fact likely to move (Castles, 2002). This over-simplified view is based on 'common sense' rather than on an understanding of the complex relationship between environmental change (and perceptions of it) and human agency, which includes adaptation that reduces the need to move away from affected areas, as well as the multiple factors that affect migration decisions. It also overlooks the fact that migration requires financial resources and social support, both of which may decline with climate change, thus resulting in a reduction, rather than an increase, in the number of people able to move.

There is also little evidence that people who have already been exposed to environmental degradation actually do move in the ways and numbers predicted by the environmental refugees' model. New research and reviews of existing information (for example, Brown, 2008; Hugo, 2008; Morrissey, 2009; Piguet, 2008; Raleigh et al., 2008) are building a clearer picture of how climate change may affect migration. Predicting future climate change, however, is inherently uncertain. For example, while global warming in the 21st century will be more intense in Africa than in the rest of the world (with average temperature rise 1.5 times greater than at the global level), the results of rainfall projections remain uncertain, and no conclusions can be drawn for West Africa (ECOWAS/SWAC, 2008). This clearly makes understanding and predicting the impacts of climate change on human societies extremely difficult, especially the long-term impacts that can be mediated by adaptive capacities. With this in mind, the best approximation—with all its limitations—is to use the experiences of past and current events as analogous to climate-change-induced drought, desertification and land degradation, extreme weather events such as floods and hurricanes and, obviously to a much lesser extent, sea level rise.

Drought, desertification and land degradation

Freshwater availability is predicted to decrease and to affect between 75 and 250 million people in Africa by 2020, and up to a billion people in Asia by 2050 (IPCC, 2007). These figures represent the number of people living (or, more often, estimated to live) in areas at risk, but not necessarily those directly affected by water shortages. It is important to note that water stress does not necessarily imply inadequate access to water for domestic purposes, especially for urban households. Statistically, households in countries facing water stress are no more likely than those in other countries to lack access to improved water supplies. There is also considerable case-specific evidence of cities with plentiful water resources where poor households do not have adequate access to affordable water and cities with scarce water resources where poor households are comparatively well served (McGranahan, 2002). Decreases in rainfall can, however, affect people in economic terms, for example, through a decline in agricultural productivity, and thus be a contributing factor to mobility.

The links between drought, desertification and migration are complex, and much of the existing literature draws on analogies with the drylands areas of Africa, where climatic fluctuations, as well as widespread mobility, have always been a defining feature. Research in northern Mali in the late 1990s found that up to 80 per cent of households interviewed had at least one migrant member, but this high level of mobility was related more to the pursuit of economic opportunities and the need to diversify income sources than a direct consequence of desertification and land degradation (GRAD, 2001). In the same region, the drought of 1983-1985 affected local migration patterns, with an increase in temporary and short-distance movement and a decrease in long-term, intercontinental movement (Findley, 1994). Recent research in Burkina Faso suggests that a decrease in rainfall increases rural-rural temporary migration; on the other hand, migration to urban centres and abroad, which entails higher costs, is more likely to take place after normal rainfall periods and is influenced by migrants' education, the existence of social networks and access to transport and roads (Henry et al., 2004). These findings mirror those of research in other contexts: In Nepal, land degradation and environmental deterioration lead mainly to local movements, although the better educated tend to move to urban centres farther away (Massey et al., 2007).

These overall patterns also vary depending on individual and household circumstances. Gender is an important variable determined by the locally prevailing gender relations and divisions of labour. Hence, since marriage is their main reason to move, women in the Sahel are less likely than men to engage in short-term movement (Henry et al., 2004). In Nepal, where women have primary responsibility for agricultural production, they are significantly less likely than men to move to distant destinations (Massey et al., 2007). The migration patterns of wealthier, better educated and better socially connected groups seem to be relatively unaffected by environmental degradation. Younger, landless households with few dependents are more likely to move permanently than those who own land and property in the affected area (Massey et al., 2007; McLeman and Smit, 2004). However, impoverished groups with limited resources to invest in migration are less likely to move, and their ability to cope will be increasingly determined by the availability of locally based opportunities for income diversification.

The impacts of slow-onset climate change are also more likely to affect politically and economically marginalized groups, especially where local institutions are unable to mediate growing competition for resources. Pastoralist groups have long developed strategies to cope with unpredictable environments, and mobility of families or parts of families for pastoral production, including seasonal transhumance and travel to markets, is a key element of such strategies. However, decreasing rainfalls and more frequent droughts will put more pressure on pastoral resources, pushing pastoralists further away from their traditional migratory routes. It is often thought that this, in turn, will increase conflict between nomadic pastoralists and sedentary farming communities over dwindling resources, and Darfur is often cited as an example. However, in this case—and probably in many others—conflict is the result of a combination of environmental pressures and the breakdown of traditional social structures and well-established local mediation and dispute resolution mechanisms (Edwards, 2008). Throughout drylands Africa, years of political and economic marginalization of pastoralist groups, inappropriate development policies constraining mobility, much lower access to basic services than national averages and limited opportunities for income diversification have been important factors in the propensity of pastoralists to migrate to urban centres (Hesse and Cotula, 2006; Oxfam International, 2008). Changes in traditional migratory routes and migration to seek alternative livelihoods are valid responses to changing environmental contexts, and both need to be better supported.

Extreme weather events

In many cases, floods and hurricanes, especially when accompanied by landslides, force people to leave their homes and move to other areas. Displaced people are often extremely vulnerable, and, in most cases, experience shows that they return as soon as possible to reconstruct their homes and livelihoods (Perch-Nielsen and Bättig, 2005; Piguet, 2008; Raleigh et al., 2008). Extreme events only become disasters when they affect populations with high levels of vulnerability. Repeated events and limited access to government and non-governmental support systems are important factors in increasing risk. This is not only the case for low- and lower-middle income countries: Poor communities in New Orleans, for example, were much more affected by Hurricane Katrina than wealthier groups, partly because of the location and conditions of their houses, and partly because of lack of insurance. As a result, poor groups were the majority of permanent out-migrants from the city (Morrissey, 2009). In contrast, in the aftermath of the Indian Ocean Tsunami in 2004, out-migration was limited, and mass migration never occurred. This is attributed to a variety of factors, not least of which is the rapid humanitarian response and the substantial mobilization of diaspora groups to support victims at home (Naik et al., 2007). Similarly, a study of the impact of the 14 April 2004 tornado in Bangladesh found that it had little if any consequences on out-migration from the affected areas, as aid and recovery packages were distributed rapidly and fairly, and the event itself was perceived as exceptional and unlikely to occur again (Paul, 2005).

The importance of effective coping strategies by communities and governments is illustrated by the different impacts of two natural disasters. After the Kobe earthquake in Japan in 1995, 300,000 people were displaced, but, within three months, only 50,000 had not returned home; in contrast, many of the people displaced by the eruption of Mount Pinatubo in the Philippines in 1991 were still in temporary camps or squatter settlements after several years (Castles, 2002).

Sea level rise

Sea level rise is a long-term, gradual process of inundation and is also a contributor to the severity of storm surges and flooding. This makes it a major threat for the inhabitants of small island states, especially those with low elevation above sea level, and also for those living in flood plains close to the sea or tidal rivers or those living in cyclone-prone coastal zones. Over 600 million people (10 per cent of the world's population) are estimated to live in coastal zones with an elevation of up to 10 metres (about 2 per cent of the world's land area). Of these, 360 million live in urban areas (13 per cent of the world's urban population), and about 247 million live in low-income countries (McGranahan et al., 2007). Obviously, the actual number at risk from sea level rise and storm surges over the next few decades is probably smaller than this, but there are no reliable figures for the numbers or proportions of people living in coastal areas lower than 10 metres above sea level. Whether migration will be the main response to sea level rise will depend on the capacity of communities and governments to respond with a range of options, such as increased protection infrastructure, the modification of land use and construction technologies and managed retreat from highly vulnerable areas (Perch-Nielsen, 2004). Ironically, some of the areas most at risk are also major migrant destinations since they offer better economic opportunities through their concentration of industry and services. Measures to support a more decentralized pattern of urbanization and industrialization would help reduce the numbers of people living in areas at risk and, at the same time, reduce regional inequalities that are a root cause of migration.

In summary, research on contexts that offer similarities to the situations predicted for the impacts of climate change suggest that environmental degradation does not inevitably result in migration. Where it does, it is likely that movement is predominantly short term, as in the case of extreme weather events and natural disasters, and short-distance, as in the case of drought and land degradation. In the case of rising sea levels, much less can be inferred from past experience, and the number of people forced to move will depend on adaptation initiatives as well as on wider national planning strategies. The significance of non-environmental factors in migration, the uncertainty of the extent of changes in rainfall patterns and tropical cyclone/hurricane/typhoon frequency and strength as a consequence of climate change, and the fact that predictions only go as far as the next 50 years, are serious limitations for any realistic long-term assessment of the link between climate change and migration. At the same time, however, there are clear pointers to the need to understand migration as one in a range of strategies that individuals and households can use to adapt to climate change.

Income Diversification and Circular Mobility as an Adaptive Response to Slow-onset Climate Change

The prevalence of short-distance, circular migration as a result of land degradation and desertification, especially in areas relying primarily on rainfed agriculture, is effectively a form of income diversification that may involve the same activity—farming—in other locations, or temporarily engaging in non-farm activities, especially when less labour is required in the fields. Household members may also move to urban centres, especially where there is demand for migrant labour, and send home remittances on a regular basis. It can be expected that, based on existing patterns and trends, such income diversification will become an increasingly important element of adaptation to slow-onset climate change.

There is little research that directly explores the impact of environmental factors on income diversification and mobility. However, there is much evidence showing that these interrelated strategies are substantial elements of the livelihoods of both rural and urban populations. In China, for example, a 1994 survey by the Ministry of Agriculture suggested that non-farm incomes and internal transfers from rural migrants to urban centres were about to overtake earnings from agriculture in rural household budgets (Deshingkar, 2006). In India, remittances accounted for about one third of the annual incomes of poor and landless rural households (Deshingkar, 2006). Earnings from non-farm activities were also substantial and were estimated to account for between 30 and 50 per cent of rural households' incomes in Africa, reaching as much as 80-90 per cent in Southern Africa, about 60 per cent in Asia (Ellis, 1998) and around 40 per cent in Latin America (Reardon et al., 2001). In Bangladesh, between 1987/1988 and 1999/2000, income from agriculture declined from 59 to 44 per cent of rural households' budgets, while income from trade, services and remittances grew from 35 to 49 per cent (Afsar, 2003).

Remittances and earnings from non-farm activities have proved to play a major role in financing innovation and intensification of farming in Africa (Tiffen, 2003) and in Asia (Hoang et al., 2005; Hoang et al., 2008). On the one hand, income diversification provides the capital needed to invest in agricultural production—inputs, infrastructure and sometimes waged labour. On the other hand, income diversification also provides the safety net that enables farmers to take the risks inherent in changing long-held practices. As such, it is an essential element of agricultural adaptation to climate change.

The extent of temporary, circular and seasonal migration that often underpins income diversification is usually underestimated. In part, this is because these movements tend to elude national statistics and census data. However, estimates suggest that the numbers involved are striking. In Thailand, one third of all internal migration in the early 1990s was estimated to consist of temporary movement to Bangkok's metropolitan region during the dry season, when labour demand for agricultural work decreases (Guest, 1998). In India, an estimated 20 million people migrate temporarily each year (Deshingkar, 2006). Most of this movement is between rural drought-prone regions to rural areas of irrigated agriculture which require seasonal labour. There are, however, signs that the combination of agricultural mechanization and demand for unskilled and semi-skilled workers in the construction sector is re-orienting migrants towards urban centres and non-farm occupations. In northern Bihar, for example, temporary movement to urban centres has grown from 3 per cent of the total in 1983 to about 24 per cent in 2000 (Deshingkar, 2006).

The preference for urban destinations supports the view that increasing numbers of short-term migrants opt for employment in non-farm activities. In Burkina Faso, circular movement involving returning to home areas within two years is especially high among those engaging in cross-border migration but also applies to rural-urban migrants and, to a lesser extent, rural-rural migrants (Henry et al., 2004). In Viet Nam's Red River Delta, it is increasingly common for farmers to move to urban centres to work in the construction sector for a few months every year and then return to their villages (Hoang et al., 2005). In China, in 1999, about 60 per cent of registered migrants in the industrial and construction hubs in the coastal region had lived in their current place of residence for less than one year, and only between 15 and 30 per cent intended to settle there permanently (Zhu, 2003).

In urban centres in Africa, research shows that both wealthy and poorer groups tend to invest in property in rural areas, often their home villages, as a safety net against economic and political crises (Kruger, 1998; Smit, 1998). Recognizing these investments and ensuring that both short- and long-term migrants retain rights in their home areas is important, especially for the groups most vulnerable to loss of property and incomes. The current economic downturn is showing just how important this is: In February 2009, the Chinese Government estimated that 20 million, or 15.3 per cent of its rural-urban migrant workers, had been forced to return to the countryside because of job losses linked to the global economic downturn (Xinhua News, 2009). Rural safety nets also proved to be critical for urban residents in many African countries during the 1990s and have certainly facilitated return urban-rural movements (Jamal and Weeks, 1988; Potts and Mutambirwa, 1998).

Employment insecurity, the high cost of living and often unsafe and insecure accommodation in urban centres arguably act as contributing factors to circular migration and combine with environmental degradation in home areas in increasing people's mobility. The spatial distribution of economic opportunity will, however, remain the key determinant of migration directions, as well as a primary focus for policy action.

Accommodating and Supporting Mobility: Small Urban Centres and Institutions

Since climate stress almost invariably overlaps with socio-economic, political and cultural factors in determining migration duration, direction and composition, these other factors need to be integrated in adaptation policies. Moreover, agricultural adaptation initiatives should not assume that they ought to contribute to reducing out-migration—especially rural-urban migration—as there is ample evidence to show that rural development usually has little effect on migration and, where it does, it tends to encourage rural-urban migration (Beauchemin and Bocquier, 2004; Deshingkar, 2004; Henry et al., 2004; Hoang et al., 2008; Massey et al., 2007). This does not mean that rural development should not be a priority, especially when the majority of the population lives in rural areas. Broader agricultural and rural development, and specific climate change adaptation actions to support these, should not be linked to the reduction of migration. Changing opportunities in urban centres as a result of economic downturns are more likely to affect migration patterns, as is currently the case.

Environmental degradation will in all probability contribute to the growing need to ensure access to non-farm economic activities, either locally or involving some level of mobility. In many cases, local small towns or large villages are where these activities are concentrated. Indeed, the potential role of small and intermediate urban centres in economic growth, poverty reduction and, more recently, adaptation to the impacts of climate variability has been attracting the attention of policymakers since the 1960s. Small towns in agricultural areas are especially important for the livelihoods of the poorest groups, who are often landless and without the means to migrate to larger cities, by providing access to non-farm activities that require limited skills and capital (Hoang et al., 2008). They also play an important role in the provision of basic services such as health and education to their own population and to that of the surrounding rural area. This is likely to become increasingly important because of slow-onset climate change and the increase in the frequency and intensity of extreme events. Moreover, small and intermediate urban centres are essential components of national policies that aim to achieve a more decentralized pattern of urbanization across regions—and this is especially important in view of the concentration of large cities in low elevation coastal zones that are vulnerable to sea level rise (McGranahan et al., 2007).

Many of the policies instituted for small-town and regional development since the 1960s, however, have had very limited success, partly because of their top-down nature that neglected the importance of local characteristics and partly because they overlooked the critical importance of national macroeconomic policies in local development (Satterthwaite and Tacoli, 2003). Hence, while small towns can play a crucial role in adaptation to climate change, this can only be achieved within a broader approach to development and poverty reduction. Local small and microenterprises—in most cases the backbone of small towns' economies and where low-income groups are concentrated—need access to markets, outside capital resources and technical knowledge. As important market nodes for agricultural production, small town traders are essential for smallholder farmers; however, they cannot replace access to the land, credit and inputs that enable family farmers to respond to changes in demand (Satterthwaite and Tacoli, 2003). Perhaps most important, local governments in small towns in too many cases lack the capacity, resources and support from higher-level government.

One area where local governments in small towns need to improve their capacity is in the provision of services to migrants and the protection of their rights. Poor migrants in smaller urban centres can be more disadvantaged than migrants in the large cities because of the limited existence of the civil society organizations that can support their interests. Hence, migrants are often paid less by their employers than non-migrants, partly because they may not be aware of the prevailing wages and they are usually not members of workers' unions and associations (Deshingkar et al., forthcoming). In many instances, their willingness to accept lower wages may put them at odds with non-migrants, resulting in further marginalization and increased exposure to occupational health hazards (Hasan and Raza, 2009). They are also less likely to be able to access public services that require registration with local authorities, such as ration cards in India. At the same time, they are often registered on voters' lists and are manipulated by local politicians who do not represent their needs and priorities (Deshingkar et al., forthcoming). Overall, however, whether in large cities or in small towns, poor temporary migrants share many of the vulnerabilities of the urban poor. Perhaps the main difference is that they tend to be even less visible and therefore have even less political representation and voice.

Conclusions

Predicting the impact of climate change on population distribution and movement is fraught with difficulties. However, it seems unlikely that the alarmist predictions of hundreds of millions of environmental refugees will translate into reality. What is more likely is that the current trends of high mobility, linked to income diversification, will continue and intensify. Past experiences suggest that short-distance and short-term movements will probably increase, with the very poor and vulnerable in many cases unable to move. Underlying these trends is the growing need for the diversification of income sources and the spatially unequal distribution of economic opportunities. The centrality of both of these issues to adaptation initiatives cannot be over-emphasized. What is also necessary is a radical change in the perceptions of migration. Most migration management policies try to influence the volume, direction and types of population movement. However, policies might more usefully aim at accommodating the changes in migration patterns that result from environmental degradation, economic growth or crisis and other, wider transformations. This seems to be an essential element of adaptation to climate change and other development goals.

Notes

1 The 200 million figure is from Norman Myers (2005); the 1 billion figure is from Christian Aid (2007).

2 There is also a strong statistical association between urbanization and increases in the proportion of GDP generated by industry and services and the proportion of the labour force working in these sectors.

3 There are exceptions, and these include some of the most populous countries in the world, notably China and Indonesia (United Nations, 2008a).

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7

Climate-related Disasters and Displacement: Homes for Lost Homes, Lands for Lost Lands

Scott Leckie

Introduction

Everyone working in the field of climate change knows full well that it will lead to mass displacement. No one, however, knows how large the scale of this eventual displacement will be. Whether 150-200 million people are eventually displaced by climate change, as is most commonly asserted, or if one billion lose their homes, lands and, most important, their financial assets, as several prominent non-governmental organizations (NGOs) have predicted in worst case scenarios, or even if only several million face the reality of forced climate migration, it is clear that displacement caused by climate change will have severe and long-lasting repercussions on human rights, security and land use (Brown, 2008).

If a human rights approach—as opposed to a purely humanitarian or other approach—is taken towards this question, then what is needed in the first instance are laws and policies that, in effect, ensure houses for lost houses and land for lost land. Anything short of that will fail the human rights litmus test. Viewing forced climate displacement as a human rights issue—grounded as this is within the international human rights regime as the principle of *the inherent dignity of the human person*—forces us to take a more caring, practical and concrete perspective on the measures required to adapt to the displacement caused by climate change. This is because a human rights approach to this serious matter implies above all that each and every single person who is forced from his or her home, land or property must have a *remedy* available which respects, protects and, if necessary, fulfils his/her rights as recognized under international human rights law. For there to be a sense of climate justice, climate-displaced persons need to be ensured a home for a home and land for land. This is the basic message that needs to be sent to all states, all intergovernmental organizations and all people of good will the world over.

Fortunately, the human rights dimensions of climate change are receiving ever greater attention. The United Nations Human Rights Council has issued studies on this question. Governments heavily affected by climate change, in particular, Kiribati, the Maldives and Tuvalu, have led the way in raising the human rights elements of climate change to the higher echelons of international policymaking, and a growing number of civil society groups are playing an ever more direct role within the context of climate change in a myriad of ways (Displacement Solutions, 2009).

The consequences of climate change can affect the full spectrum of civil, cultural, economic, political and social rights, including the right to life, the right to water, the right to freedom of expression, the right to health, the right to food, the right to an adequate standard of living, the right to political participation, the right to information, the right to be free from discrimination, the right to equal treatment, the right to security of the person and a host of other rights. These rights should have a direct bearing on a wide cross-section of climate change decisions made by governments, which in turn will determine the consequences of these decisions and how the impact of climate change will be experienced by individual rights-holders (Displacement Solutions, 2009).

If the focus is solely on the displacement dimensions of climate change, a variety of rights can be found within the international human rights legal code that are particularly relevant to the discussion of climate-change-induced displacement. These are far more extensive than is commonly assumed and include:

- The right to adequate housing and rights in housing;
- The right to security of tenure;
- The right not to be arbitrarily evicted;
- The right to land and rights in land;
- The right to property and the peaceful enjoyment of possessions;
- The right to privacy and respect for the home;
- The right to security of the person;
- The right to housing, land and property (HLP) restitution/compensation following forced displacement;
- The right to freedom of movement and to choose one's residence.

When all of the entitlements and obligations inherent within this bundle of HLP rights are taken together, it is apparent that people everywhere are meant to be able to live safely and securely on a piece of land, to reside in an adequate and affordable home with access to all basic services and to feel safe in the knowledge that these attributes of a full life will be fully respected, protected and fulfilled. The normative framework enshrining these rights is considerable and is constantly evolving and ever expanding. Combining the sentiments of the Universal Declaration on Human Rights, the Covenant on Civil and Political Rights, the Covenant on Economic, Social and Cultural Rights and a range of other treaties, together with a vast array of equally important instruments and interpretive standards, such as the United Nations Committee on Economic, Social and Cultural Rights General Comment No. 4 on the Right to Adequate Housing, General Comment No. 7 on Forced Evictions and General Comment No. 15 on the Right to Water and the UN's Guiding Principles on the Rights of Internally Displaced Persons, the UN "Pinheiro" Principles on Housing and Property Restitution for

Refugees and Displaced Persons of 2005 and many others, leads to a very considerable body of international human rights laws and standards which can be used by governments to build the legal, policy and institutional frameworks required to ensure that any rights related to climate change will be upheld, particularly those involving durable solutions to displacement.

Thus, as far as human rights laws go, there is a reasonably strong basis from which to demand positive and well-planned actions by states and others to develop the means necessary to protect and secure all of these rights for climate-displaced persons. However, when the performance of states and the international community over the past 60 years of the human rights experiment is considered, and when the voices of the hundreds of millions of rights-holders throughout the world who remain as far as ever from enjoying their legitimate HLP rights are heard, it can be quickly surmised that solving the HLP consequences of climate change is going to be far from a simple task. Indeed, the prospects of achieving this are truly daunting and will require leadership, commitment and creativity the likes of which the world has all too rarely seen in recent decades. This is where the necessity of adaptation and human rights must converge and together build a stronger and more vibrant response than has been witnessed to date.

Indeed, the people of the world's 191 nations *already* face a severe, massive and dramatic global housing crisis. Well over one billion people—one in every six human beings alive today—spend their lives in one of the more than 200,000 slums that dot every corner of the planet. If recent predictions hold true, as they almost surely will, two billion or more slum-dwellers can be expected by 2030. This crisis does not bode well for the displacement to come as a result of climate change. If governments, which already have legal obligations to ensure access to adequate and affordable housing for everyone, have all too often failed in achieving these objectives, and if ordinary citizens in Egypt, India, Botswana, Dili, Belgrade, Detroit and elsewhere are increasingly less likely to be able to afford safe, secure and decent homes in accordance with their rights, how can it possibly be expected that things will suddenly improve for climate-change forced migrants, simply because the nature of their displacement and their misery may be of a different, more environmentally-based source?

Beyond the current global housing crisis—which policymakers, states, the United Nations and the donor community continue, in most respects, effectively to ignore—it must be noted that the mass of humanity who have faced forced displacement in past decades—caused by conflict, by investor greed, by poorly planned development, by disasters, earthquakes, floods, tsunamis and more—have lost their homes and lands due to these events. Sadly, far too few have seen either their rights respected or a slow, gradual improvement in their housing and living conditions once the circumstances leading to their displacement have ended or been altered. This must be remembered and placed at the forefront of human-rights-based strategies to address the displacement dimensions of climate change. Whether as a result of dam displacement in China, conflict displacement in Sri Lanka, Iraq or Bosnia, discriminatory displacement by Israel or tsunami displacement in Aceh, the track record of most countries in treating victims of displacement as rights-holders, in particular HLP rights-holders, is very poor.

There are, of course, some positive highlights, for instance, the increasing recognition of the right of refugees and displaced persons to return to their original homes and the realization by growing numbers of international agencies that displacement (often labelled as involuntary resettlement) should be a last policy option rather than the first one. But overall, the situation and the perspectives taken by too many important and powerful actors remain alarming and constitute yet another serious obstacle which must be taken into account in developing rights-based responses to the displacement caused by climate change.

Building Housing, Land and Property Rights into the Package of Solutions for Climate-induced Displacement

The human rights dimensions of climate change have, indeed, been increasingly recognized and, to a very small degree, acted upon. What has not yet happened, however—with the exception of several valiant efforts that will be described below—is the development of detailed, well-resourced and concerted efforts to find sustainable, rights-based solutions to all of the various types of displacement that are being, and will be, caused by climate change. Given this reality, the questions must be asked: What are the real HLP options for those who are forcibly displaced by climate change in coming years? Can an effective rights-based response to climate-change-induced displacement be encouraged so that it generates *solutions* to the emerging crisis that show humanity's best sides?

The answer to the latter question is a solid 'yes', and to develop such responses there first must be an understanding that not all types of displacement caused by climate change will necessarily have the same consequences. In fact, there are at least five different types of climate-induced displacement, each of which will require different remedies. In the most general of terms, displacement due to climate change is likely to manifest in five primary ways:

Temporary Displacement: People who for generally short periods of time are temporarily displaced due to a climate event such as a hurricane, flood, storm surge or tsunami but who are able to return to their homes once the event has ceased.

Permanent Local Displacement: People who are displaced locally but on a permanent basis due to irreversible changes to their living environment, in particular sea level rise, coastal inundation and the lack of clean water, and increasingly frequent storm surges. This form of displacement implies that localized displacement solutions will be available to this group of forced migrants, such as providing higher ground in the same locality.

Permanent Internal Displacement: People who are displaced inside the border of their country, but far enough away from their places of original residence that return is unlikely or impossible. This would involve, for example, a family displaced from one region of a country to another region in the country, for instance, from a coastline to an inland town or city.

Permanent Regional Displacement: People for whom displacement solutions within their own countries are non-existent or inaccessible and who migrate to nearby countries willing to offer permanent protection. This would include, for instance, a citizen of Vanuatu or Kiribati migrating on a permanent basis to New Zealand.

Permanent Inter-continental Displacement: People for whom no national or regional displacement solutions are available, and who are able to receive the protection of another state on another continent, such as a Maldivian who migrates to London.

Each of these five categories, of course, has different policy and legal implications for governments, the people concerned and the international agencies tasked with assisting climate-change forced migrants to find durable solutions to their plight. Such responses, which can perhaps most usefully be understood in terms of short- and long-term options, have very important ramifications for those affected and for those involved in ameliorating the displacement crisis caused by climate change. Short-term policy responses, of course, would be similar to those already in place following many conflicts and disasters and would consist largely of shelter programmes, forced migrant camps and settlements and other short-term measures. These, in turn, would need to be augmented by local adaptation measures that preclude similar displacement in the future, e.g., by raising the floor levels of homes, etc. Long-term policy responses would be grounded more comprehensively within an HLP rights framework and would involve remedies such as the provision of alternative homes and lands, compensation and access to new livelihoods, among other policy measures, and should be based on the lessons learned from previous efforts at permanent resettlement. Problematically, the record of treatment faced thus far by those who have arguably already been displaced due to climate change does not bode particularly well for the millions yet to be displaced. As has often and appropriately been reiterated, it is not the poor who are the first to migrate from situations of crisis. Rather, the poor are most likely to be the most vulnerable victims of climate displacement, given their frequent inability to migrate in the event this becomes necessary due to the financial and other constraints they may face. The poor are always the ones left behind. Will this be allowed to occur again in the context of climate change?

Of the most well-known cases of what are seen as climate-change-induced displacements—including the Carteret and other atolls (Tasman, Mortlock and Nugeria) in Papua New Guinea, Lateu village in Vanuatu, Shishmaref and other villages in Alaska (United States) and Lohachara Island in the Hooghly River in India—none have thus far been very successful in resettling those displaced, and, in all instances, many of the human rights of those affected are clearly not subject to full compliance. If there was ever a warning, it is in the consequences now faced by those already displaced due to climate change. Resources are sorely lacking, governmental and international agency responses thus far have been exceedingly weak, and, clearly, a sense of resignation is widely apparent within the institutions that could actually do something positive for climate-displaced persons.

At the same time, work is emerging in countries that is, at last, beginning to highlight the displacement dimensions of climate change and the solutions required to deal with it. Some of this work is truly extraordinary and worthy of all types of support—financial, political, solidarity and moral. Several of the more interesting developments along these lines include the following initiatives in Papua New Guinea, Tuvalu and Bangladesh:

The Integrated Carterets Relocation Programme of Tulele Peisa (Papua New Guinea) and the Bougainville Resettlement Initiative

The work of the group Tulele Peisa ("Riding the Waves on Our Own") in Papua New Guinea (PNG) is truly path breaking and worthy of close inspection by anyone concerned with finding solutions for climate-displaced persons (see the Tulele Peisa website: www.tulelpeisa.org). Led by the dynamic Ursula Rakova from the Carteret Islands, Tulele Peisa has set out to find permanent housing, land and property solutions for the 3,000-strong population of the Carterets on nearby Bougainville Island. When the national Government of PNG and the Autonomous Provincial Government of Bougainville decided several years ago to resettle those from the Carterets and other atolls on Bougainville, many expected the relevant governmental bodies to effectively manage this process, including the identification and allocation of sufficient land on Bougainville to resettle those fleeing their atolls. After a frustrating period of inaction—which included the still unexplained non-expenditure of 2m Kina (+/- US$670,000) that had been allocated for these purposes under the national PNG budget—Tulele Peisa was founded with a view to actually finding HLP solutions for those to be displaced.

Working against the odds and with very limited financial resources, Tulele Peisa thus far has been able to amass some 300 acres of land on Bougainville, most of which has been donated by the Catholic Church for the purpose of resettling a portion of the Carteret Islanders. More land is obviously needed, but an important start has been made in developing the methods required to provide sustainable HLP solutions to the atoll dwellers. Displacement Solutions (DS) has been working closely with Tulele Peisa since 2008 and, through its Bougainville Resettlement Initiative, has been seeking funds to support the work of the organization. DS was also involved in putting together the components of what would have been the largest land purchase to date for the exclusive purpose of resettling climate-displaced persons. Working with one of the main private landowners on Bougainville, DS put in place a plan to assist in the sale of some 7,000 acres of private land to the Autonomous Government of Bougainville on the condition that the land—once it re-entered the public domain—would be set aside for the resettlement of the Carteret, Tasman, Mortlock and Nugeria Islanders. (A detailed description of this process is available at the DS at work section of the website: www.displacementsolutions.org.) Suffice it to say, neither local nor national government funds were forthcoming, despite the allocation of monies within the budget that could have been used for this purpose, and the private land was then sold to a foreign developer who plans to use the land for tourism and possibly agriculture. While it is still hoped that the developer will set aside a portion of the land for use by atoll dwellers, it is clear that a golden opportunity for finding land solutions for some of the first climate-displaced persons was lost.

Nevertheless, despite this and other setbacks, Tulele Peisa continues to work diligently on behalf of the Carteret Islanders to find viable land and livelihood options for them on Bougainville. With more than 96 per cent of Bougainville still under customary land ownership, finding available land for the purpose of resettlement has proven extremely challenging.

What to do about the people of Tuvalu?

As is well known, few of the countries worst affected by climate change are under as dire a threat as Tuvalu (McAdam and Loughry, 2009). Unlike the atoll dwellers in PNG, who at least can be resettled on Bougainville (which, of course, is within the same country as the atolls), and a similar but less promising situation in Kiribati which, according to the government official responsible for climate change adaptation, sees its largest atoll of Kiritimati as "our version of Bougainville as far as resettlement is concerned", Tuvalu's 10,000 inhabitants have no such domestic options available to them. It is becoming increasingly clear that third-country resettlement is in all likelihood the only viable alternative available to the population. At the moment, however, neither Australia nor New Zealand has expressed a willingness to integrate the entire population of Tuvalu into their own territories, although both countries have in place immigration programmes for a small number of Tuvaluans each year.

The land loss situation in Tuvalu is so dire, in fact, that the Prime Minister, Apisai Ielemia, issued a formal request to the Government of Australia in 2008 to cede to Tuvalu a small piece of territory for the purpose of re-establishing Tuvalu on a minute portion of what is now Australian territory. Needless to say, Australia was hesitant to support this request. But in response to the Federal Government's reluctance, and in an act of remarkable islander solidarity, representatives from the Torres Strait Islands in the north of Australia unofficially offered Tuvalu use of one of its islands to re-establish itself there. Could this be an option for Tuvalu or other islanders as things move from bad to worse?

There may be hope yet, given that Australia took in well over 200,000 immigrants from around the world in 2008, clearly proving the capacity of the regional superpower to incorporate large numbers of new arrivals every year. The recently developed Pacific labour programme in Australia is seen by many as a precursor to a larger plan down the road. This programme entitles a small number of Pacific Islanders to work in Australia within the agricultural sector and will bring ever larger numbers of Tuvaluans to its shores. At another level, in June 2009, a detailed presentation will be made in Brisbane, Australia, by a leading Tuvaluan policy analyst advocating the full-scale resettlement of the inhabitants of Tuvalu to Australia; details of this plan, however, are not yet available. Many options are under discussion now, but nothing is yet clear about the future of Tuvalu as a nation and the collective future of its citizens. Countries often come to the aid of other countries when they are illegally occupied or otherwise under existential threat. Will nations come to the aid of Tuvalu and secure its sovereignty or will the states of the world let one of their own drown forever beneath the sea?

Bangladesh: the Climate Refugee Alliance

Although the Pacific and Indian Ocean island nations receive the lion's share of attention in discussions about climate change and displacement, no country will actually be harder hit in terms of pure population numbers than Bangladesh. Already severely affected by land scarcity, overcrowding and ever-growing slums, Bangladesh has begun to witness climate-induced displacement across much of its coastline. The recent emergence of the Climate Refugee Alliance, a grouping of affected communities assisted by the Coastal Resource Centre, is a hopeful sign that more concrete moves are under way to find viable HLP options for those most heavily affected. Among other things, the Alliance has pressured the Government to set aside state land for the exclusive purpose of resettling what are being labeled 'climate refugees'. The Alliance has begun to address questions of land purchase and acquisition and the development of community land trusts which may hold promise for the millions who will be displaced due to the multiple effects of climate change. Things do, however, appear to be going from bad to worse in the affected areas, as this e-mail message from Mohammed Abu Musa of the Coastal Resource Centre sent on 29 May 2009 clearly indicates:

> *There is increasing influx of climate refugees in Khulna city. We assume that several thousand have already reached the city in the last 3 days (26-28 May '09). Room rent in slums and low cost houses has been increased by 50% and all available space has been booked in advance by the relatives (living in the city) of the people stranded in tidal saline water. We fear that the extreme poor will not be able to get any room.*

Four Practical Recommendations for Consideration

If permanent climate-induced displacement takes place without sufficient global attention, state intervention and the resources required to address it properly, the impact of climate change will be far worse than anyone could possibly wish. Not only will the impact upon local economies be dramatic, but severe asset losses, combined with dramatic increases in the world's slum and urban populations, the loss of life and livelihood, health declines and severe crises within the HLP sector will all contribute to making the problems worse long before they become better. As a start, it must be noted that the typical costs associated with involuntary resettlement in development contexts will apply, and that these are very expensive and equally resource-intensive. As much as resettlement efforts have often failed over the past decades, the situation is likely to be even worse as a result of climate change. What then can be done to improve the human rights prospects of those affected by climate change, and what specific areas of concern demand greater attention by citizens, states and the international community? While the list of possible actions is long, the following four areas require attention in the near term in order to build the capacity to better address the human rights implications of climate change:

1. The need for adequate domestic institutional frameworks to protect the rights of climate-displaced persons

When speaking about the rights of those displaced by climate change, it is first necessary to clarify which public institutions within affected countries are legally, or at least politically, responsible for resolving their plight. In determining this, forced migrants can reasonably be expected to ask several very straightforward questions:

- Where do I turn for assistance? On which door do I knock for relief and remedy?
- What rights do I have to a new home or new land?
- How long will I be homeless?
- What laws and rules are in place to ensure the enforcement of my rights?
- Am I entitled to compensation or reparations?

In far too few countries—in fact, in virtually none—can these and related questions easily, adequately and quickly be answered by public authorities. This is not to condemn, but rather to simply point out that good planning, good institutional frameworks, good laws and good policies are all required for successful adaptation to current and future climate change challenges. Human rights law and the growing number of judicial decisions on HLP rights, in particular, show that *planning*—that seemingly most innocuous dimension of governance—is, in fact, one of the most important roles any responsible government can play in taking HLP and other rights seriously. In fact, it could be argued quite convincingly that adherence to the most important human rights treaties, laws and principles obliges states to plan appropriately. Indeed, human rights laws require states not only to plan, but to carefully diagnose domestic human rights challenges, to develop laws and policies adequate to address these and to ensure that remedies of various sorts are available to individuals and communities unable to enjoy, or who are prevented from enjoying, the full array of human rights protections.

2. The need for adequate international institutional frameworks to protect the rights of climate-displaced persons

The painful lack of a specific international institutional framework with a recognized mandate to protect the rights of climate-displaced persons has been the subject of a growing global debate on how to ensure that forced migrants no longer fall through the cracks of the international protection and/or humanitarian regimes. Some have suggested that the 1951 UN Refugee Convention and its 1967 Protocol be structurally revised with a view to expanding the UN High Commissioner for Refugees' (UNHCR) mandate to include assistance to and protection of climate-displaced persons. Extending the coverage provided within the Refugee Convention, however, is far from assured, and there is considerable reluctance both within UNHCR and, in particular, from the donors that support it to make the giant institutional leap towards providing structural assistance to climate-displaced persons. At the same time, would it truly be wiser to attempt to build a new global institution to be in charge of climate migrants rather than to allow other existing international organizations concerned with migration or other issues—but which do not necessarily ground their work in human rights norms—to bear responsibility for the huge and long-term tasks associated with protecting the basic rights of climate-displaced persons? The answer is 'no'.

Rather, the time has come for states and UNHCR to begin systematically to examine the implications of incorporating these issues into both their legal mandates and their day-to-day operations. In doing so, UNHCR would surely work closely with states, other United Nations and international organizations and with NGOs and the migrants themselves in pursuing *solutions* that are grounded deeply in the spirit and letter of human rights. And yet while there is surely some support both within UNHCR and outside the organization for doing so, convincing donors and the leadership of UNHCR to embrace these challenges will be a major undertaking, which by no means is assured of success. If the history of the involvement of UNHCR in issues of internally displaced persons (IDPs) is anything to go by, it could takes years before climate-displaced persons find a home within the organization, and a delay such as this simply will not do. UNHCR is the right institution to protect climate-displaced persons, but to do so it must act now, together with donors, to broaden its mandate in a rapid and fully resourced manner. Changing the 1951 UN Refugee Convention might not work, but suggesting a new Protocol to the Convention may well yield results.

3. Facilitating the evolution of international law

Another useful step that should be pursued is the development of a comprehensive international standard on the rights of climate-displaced persons. Several recent initiatives have made important contributions to the thinking required to adopt a new standard. The Declaration of the Fourteenth SAARC (South Asian Association for Regional Cooperation) Summit called for adaptation initiatives and programmes; cooperation and early forecasting, warning and monitoring; and sharing of knowledge on the consequences of climate change in order to pursue climate-resilient development in South Asia. In a more targeted manner, the Malé Declaration on the Human Dimension of Global Climate Change, adopted on 14 November 2007, makes frequent reference to human rights principles, including the fundamental right to an environment capable of supporting human society and the full enjoyment of human rights. This Declaration urges participants at the Bali Conference of the Parties of the UN Framework Convention on Climate Change to pay greater attention to the human dimension of climate change. It also seeks the increased engagement of the UN Office of the High Commissioner for Human Rights on climate change issues.

One important outcome of the increased attention to the human rights implications of climate change would be the adoption of a new international standard on these issues. Texts developed in recent years—the Malé Declaration, among others—provide a useful starting point for further work in this regard. Such a standard, or perhaps even a composite group of standards which together would constitute international principles on the relationship of climate change and human rights, could, if formulated properly, be of considerable assistance to national governments seeking guidance on addressing these challenges, as well as to the international community and individual rights-holders in determining where rights and responsibilities begin. It would be equally important to determine precisely what form such a new standard might take. Some have suggested simply amending the Refugee Convention. Others have proposed additional options including treaties and other binding law. The experience of the past decade, as it relates to the treatment of all displacement issues by the international community, at least as far as new standards are concerned, clearly shows that there has been an overwhelming preference for developing new soft law standards (guidelines, guiding principles, basic principles, general comments and so forth) rather than entrenching rights of this nature—which in many respects are HLP rights—into new binding treaties. For instance, with regard to the question of internal displacement—which is very relevant to the climate change debate—the importance of the UN's Guiding Principles on the Rights of Internally Displaced Persons (1998), the UN "Pinheiro" Principles on Housing and Property Restitution for Refugees and Displaced Persons (2005) and the Inter-Agency Standing Committee's Operational Guidelines on Human Rights and Natural Disasters (2006) is apparent, but none are as legally strong as proponents of the rights of IDPs may wish. At the same time, it must be reiterated that these and similar texts do achieve results that are greater than their drafters may have ever envisaged.

Understanding this, therefore, two routes of action could be chosen. One could be the creation of a new standard, similar to those adopted during the past ten years. This process can be achieved reasonably rapidly without the type of resources and political anxiety that so often accompanies the treaty-making process. In fact, achieving recognition of such a standard—perhaps called the UN's *Human Rights Guidelines On Climate Change*—could be quite fast, and, if the resources and interest are apparent, there would be no reason why such a standard could not be approved either at the next climate talks in Copenhagen in 2009 or by the UN General Assembly or

UN Human Rights Council even sooner than that. A second option, a new treaty, certainly could also be a possibility, though this would demand time, effort and resources of a significantly higher order.

4. The land challenge: Land banking and expropriation as fundamental domestic remedies

Finally, governments throughout the world should be encouraged to review public land holdings and domestic legislation as they relate to questions of expropriation of land for public purposes. It is widely agreed that climate-change-induced displacement, among other things, will put immense pressure on cities and the slums that surround them. Indeed, without appropriate adaptation measures, the world's slums will grow at a far faster rate and, in turn, create health, social, economic and other crises far worse than many would now predict. To assist in reducing these pressures, governments everywhere should begin identifying unused land for possible future use to resettle people and their communities should this become necessary. This is a complex issue with innumerable dimensions, but few governments are structurally unable to at least begin the land identification process as a part of the planning process related to the challenges of climate change.

In summary, when people are threatened with the loss of their homes, lands and properties due to climate change, there is a need to be realistic and to acknowledge that this is not solely about circumstances such as those facing the Maldives, Kiribati, Tuvalu and other small island states. Indeed, only a small fraction of likely future displacement will occur in small island states, and, even here, perhaps less than one million people will require permanent regional or inter-continental resettlement. This is a tragedy for all of those islanders who lose their homes, but it is a tragedy of a scale that can be managed sustainably and within a human rights framework.

The vast majority of eventual displacement due to climate change is set to occur along vulnerable coastlines in some of the world's poorest countries and in inland areas that are increasingly made inhospitable due to steadily worsening climate events such as droughts, floods and storms. None of this in any way detracts, of course, from the fact that small island nations remain—under human rights laws—responsible for securing the rights (including HLP rights) of all citizens and lawful residents within their territories, up to *the maximum of their available resources*, and that the international community, in turn, has *responsibilities to protect* when states are no longer willing or capable of protecting basic rights, including HLP rights.

What is unique and particularly tragic with respect to small island nations is the unimaginable prospect not only of displacement on a massive scale, but the possibility that entire nations may become completely incapable of sustaining populations, and, in some dire instances, may eventually cease to exist all together. This is surely one of humanity's greatest tragedies, a preventable wrong which simply must affect all the world's citizens. Using the power of human rights to find housing, land and property solutions in all countries affected by climate change is one means by which this challenge can most effectively be met.

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8

Children in the Context of Climate Change: A Large and Vulnerable Population

Sheridan Bartlett

Introduction

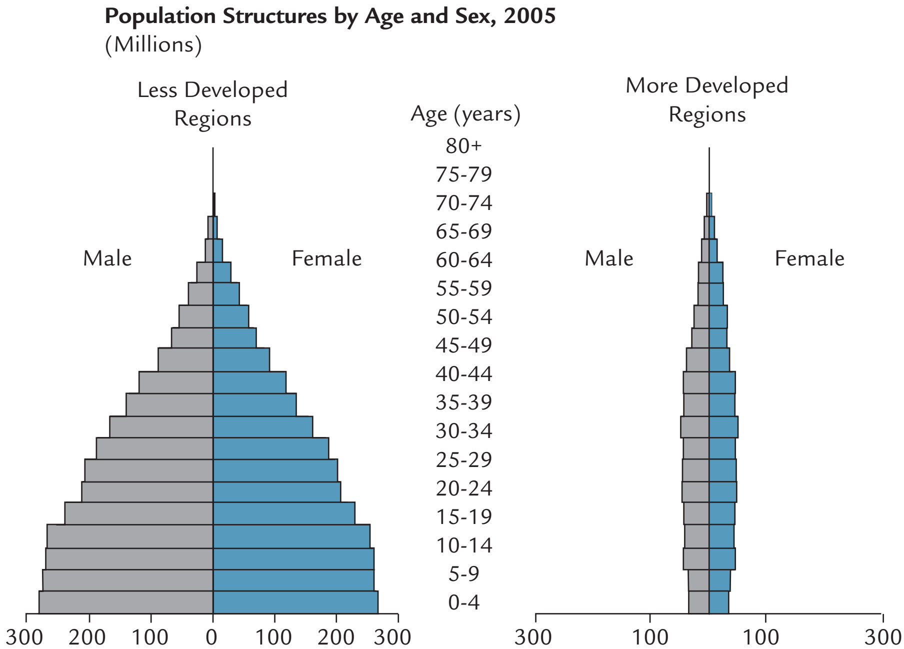
It is generally acknowledged that low-income countries and poor communities worldwide are most seriously at risk from the probable impacts of climate change. This is not because climate change will necessarily be more extreme in these places (although this will often be the case[1]), but because people, their enterprises and the places they occupy are so much more vulnerable in the context of poverty. These people are less well served by protective infrastructure and services, less able to adapt and prepare for extreme weather events and are often more dependent on local climate-sensitive resources. In urban areas especially, poor people frequently occupy the most risk-prone areas. Among these vulnerable populations, children, and, particularly, very young children, are especially at risk for a number of reasons, which will be discussed later in this chapter. The fact that children in poor countries and communities also tend to make up a very large part of the population only serves to heighten the concern. In order to be most effective, measures taken to adapt to climate change must take into account the disproportionate and often different ways in which children can be affected, bearing in mind not only their substantial presence and their vulnerability, but also their potential resilience, with adequate support, and their capacity to contribute actively to adaptation measures.

Background

Despite the rapid global decline in fertility over recent decades, which has occurred even in most low-income countries, a very high proportion of the population in these countries still consists of children and adolescents (Figure 8.1).[2]

In high-income countries, people under 18 make up about 20 per cent of the population. In many of the low-income countries most exposed and most vulnerable to climate change, they are closer to half the population (for instance, 42 per cent in Bangladesh, 51 per cent in Nigeria and 57 per cent in Uganda). Even more to the point is the proportion of highly vulnerable children under five—they make up between 10 and 20 per cent of the population in countries more likely to be

Figure 8.1: Age Distribution of the World's Population



Source: United Nations, 2005.

seriously affected (for instance, 11 per cent in India, 12 per cent in Bangladesh, 17 per cent in Mozambique and Nigeria and 21 per cent in Uganda). In higher-income countries, the proportion of under-fives is closer to 4 or 5 per cent (UNICEF, 2007).

This lopsided distribution is most apparent in sub-Saharan Africa, where over 40 per cent of the population is under 15. Here, as well as in North Africa, the Middle East and in many parts of Asia, the largest sector of the population is under five years of age. This is despite under-five mortality rates that continue to exceed 100 per thousand live births in some countries.

Within countries, differences in distribution also exist, and, again, it is often the poorest communities that have the highest proportion of children. For instance, National Family Health Survey data show an average of four children per woman among Delhi's poor compared to 2 per woman among the city's non-poor (UHRC, 2006).

The child population is expected to grow more slowly over coming decades than the population as a whole, and, in many parts of the world, it is expected to decline in number. But in those places where the proportions of children are already highest, the absolute number of children is expected to continue to grow. Over the coming decades, increasing numbers of these children will live in urban areas, often in the informal settlements and hazard-prone parts of cities which are frequently the only places where land can be found. Especially in the context of rapid urbanization, these settlements can be among the most vulnerable to extreme weather events (Parry et al., 2007). It is difficult to generalize about how urban age structures are changed by migration, since this depends, for instance, on the nature of the migration, whether it is temporary, seasonal or long term and whether migrants move individually or as families. But high levels of in-migration often increase the proportion of young adults and thus can lead to increased birth rates (although rural migrants' fertility rates tend to decline once in the urban areas). A city's age structure may also be influenced by substantial out-migration by older groups as they return to 'home' villages or towns.

What does all this mean in the context of climate change? In the broadest and most simplified terms, it means that the populations most vulnerable to the likely challenges posed by climate change are also those with the highest concentrations of children in need of care, and with the lowest ratio of caregivers and bread winners to children. This reality arguably increases the vulnerability of these populations in a rather dramatic way. Larger numbers of young children add to the burdens simply by virtue of their age and need for care. In addition, in the context of many of the risks posed by climate change, their needs are likely to intensify, since their stage of development leaves them especially vulnerable to many of the hazards. Children who become ill, malnourished, injured or psychologically affected by disasters, famines, displacement or deepening poverty will increase the challenges faced by their families and communities. With appropriate support, children can be extraordinarily resilient to shocks and stresses, but in extreme situations that affect many people, these supports may not be reliably available.

This is not the only reality posed by high concentrations of children, however. Young children unquestionably need care. Older children and adolescents need care, too, but they also can, and often do, contribute to their households and communities in a range of ways. It is easy to overlook their energy, ingenuity and eagerness to be involved in meaningful ways. Ten- to 18-year-olds are a substantial part of the population, especially in low-income countries and communities. But in terms of formal planning for adaptation and preparedness, they are a resource that is too seldom recognized and drawn upon.

Given these very basic realities, policy and planning for adaptation in the face of climate change needs to be based, among other things, on an understanding of the particular vulnerabilities of children, both girls and boys. It is also important to understand how resilient children can be and how productive and proactive in responding to challenges in their lives. Adaptation, in these terms, means considering how to strengthen and support the capacity of children and adolescents to cope with the full range of risks and adversity associated with climate change, as well as that of the families and communities on which they depend.

Understanding the Impacts of Climate Change on Children

Children, especially young children, are in a stage of rapid development and are less well equipped on many fronts to deal with deprivation and stress (Engle et al., 1996). Their more rapid metabolisms, immature organs and nervous systems, developing cognition, limited experience and behavioural characteristics all contribute to their vulnerability. Their exposure to various risks is also more likely to have long-term repercussions than for adults.

Almost all the disproportionate implications for children are intensified by poverty and the difficult choices low-income households must make as they adapt to more challenging conditions. Events that might have little or no effect on children in high-income countries and communities can have critical implications for children living in poverty. The likelihood of poor developmental outcomes is considered to increase cumulatively with the number of risks they face, whether physiological or psychological.[3] Children on the edge, like families on the edge, have fewer assets—in every sense of the word— to draw on and are more likely to be adversely affected by the various challenges imposed by climate change. At the same time, it is important to recognize that relating risks to outcomes for children is not a simple matter of accounting. Many variables come into play, including the meanings that events have for people, and these variables can relate to one another in complex ways. Children driven into work by their families' increasing poverty, for instance, may be academically disadvantaged, but they may also feel a sense of pride and achievement in their capacity to contribute that could boost their confidence and resilience (Boyden, forthcoming).

There has been little hard research on the impacts of climate change on children. Even where more general impacts are projected, figures are seldom disaggregated by age or sex. But the fact is that, in large part, the challenges associated with climate change will intensify existing difficulties, not present an entirely new set of conditions. This can legitimately be extrapolated from existing knowledge on environmental health, disaster responses, household coping strategies, the effects of poverty on children, children's resilience and the beneficial effects of their participation in various efforts. These all contribute to a picture of the implications for children and adolescents of extreme events, as well as more gradual changes, and of the adaptations that are likely to be made.

Health and survival

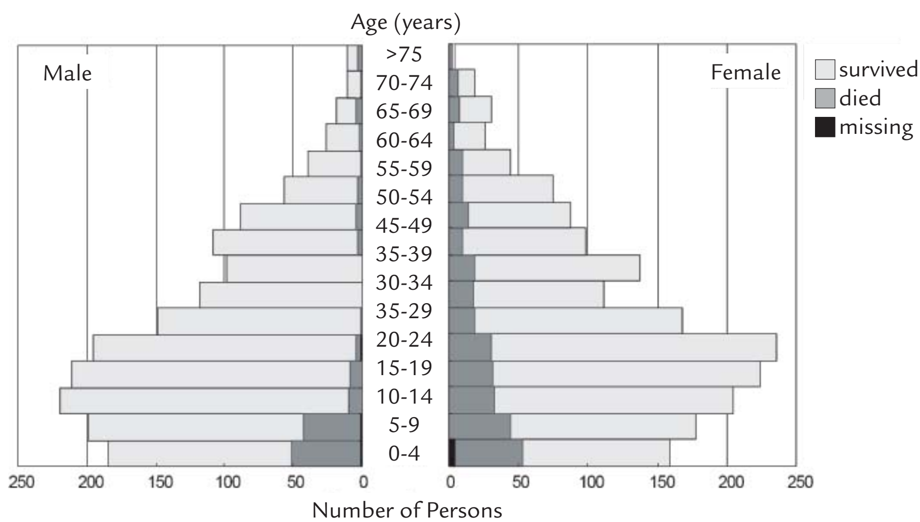
The disproportionate health burden for children of challenging environmental conditions is well documented. According to a conservative estimate, children under 14 are 44 per cent more likely to die because of environmental factors than the population at large. The same gap exists for morbidity, and it increases greatly when the potential loss of healthy life years is considered (Prüss-Üstün and Corvalán, 2006). The greater burden, especially for the youngest children, then, is not a minor matter of degree, and it is likely to be exacerbated in many places by climate change.

***Mortality in extreme events**:* In low-income countries, the loss of life during such extreme events as flooding, high winds and landslides is shown repeatedly to be disproportionately high among children, women and the elderly, especially among the poor. A study of flood-related mortalities in Nepal, for instance, found that the death rate for children aged two to nine was more than double that of adults, and pre-school girls were five times more likely to die than adult men. The risk for poor households was six times that of higher-income households (Pradhan et al., 2007).

The distribution of deaths related to the 2004 Indian Ocean tsunami followed a similar pattern, as shown in Figure 8.2 (Nishikiori et al., 2006). Although the tsunami was not related to climate change, it can still provide insight into patterns of death during an extreme event. The higher mortality rates for girls and women have been related to the fact that they are more often responsible for small children, a fact which may limit their mobility. The loss of these primary caregivers can leave surviving children and families still more vulnerable (Nishikiori et al., 2006).

In slower onset disasters such as droughts and famines, mortality rates are also much higher for young children. Situations are commonly defined as emergencies when crude mortality is 1/10,000/day and under-five mortality is double that (Sphere Project, 2004). Although the higher rate for young children is not unreasonable, given average under-five mortality rates in low-income countries (UNICEF, 2007), it nevertheless highlights a grim reality: High mortality rates for young children, which would be unthinkable in high-income countries, are routinely accepted as a baseline indicator of normality in low-income nations. And, while overall death rates for young children continue to drop in most parts of the world due to improved health care, immunization rates and environmental conditions, for many of the children most at risk from the biggest killers—diarrhoeal and respiratory diseases, malaria and malnutrition—the situation is likely to worsen with some of the effects of climate change.

Figure 8.2: Age and Gender Distribution of Tsunami-related Deaths



Source: Nishikiori , et al., 2006.

Water and sanitation-related illnesses: Children under five are the main victims (80 per cent globally) of sanitation-related illnesses (diarrhoeal disease, primarily) because of their less-developed immunity and because their play behaviour can bring them into contact with pathogens. These illnesses also results in higher levels of malnutrition and increased vulnerability to other diseases , with effects on overall development. During heavy or prolonged rains, blocked drains and flooded latrines can make contamination difficult to avoid, increasing the incidence of diarrhoeal illness in children.[4] Where the incidence and duration of rainstorms increase because of climate change, these conditions will become more prevalent. Contamination of water supplies is also a risk during droughts. After extreme events, diarrhoeal illnesses related to breakdowns in sanitation can take more lives than the initial disaster (WHO, n.d.).

Malnutrition: Malnutrition results from food shortages (as a result of reduced rainfall, other changes affecting agriculture and interruptions in supplies during sudden acute events), but it is also closely tied to unsanitary conditions and to children's general state of health. Even when there is enough food available, the calorie intake of small children in dirty surroundings may go in large part towards fighting off infection (Solomon et al., 1993). When children are malnourished, their vulnerability to infection is greatly increased, and a vicious cycle results (Lechtig and Doyle, 1996). A chronically malnourished two- or three-year-old may be at a permanent disadvantage, becoming both physically and mentally stunted (Grantham-McGregor et al., 2007). Children in Africa born in drought years, for example, are significantly more likely to be malnourished or stunted (UNDP, 2007). Research in Zimbabwe found that children who had been in the critical 12- to 24-month age group during a drought in the early 1980s were, in adolescence, an average of 2.3 inches shorter than the mean (Alderman et al., 2004).

It is important not to underestimate the long-term implications of the malnourishment that may accompany climate change—not only for the children involved, but also for their families and for society at large. Malnourishment can lead to physical stunting, but also to mental stunting and diminished potential over a lifetime. In the case of the Zimbabwean children in the research just cited, their estimated potential loss in lifetime earnings was calculated to be 14 per cent. If children are basically healthy and well fed, catch-up growth will happen quickly once recovery is under way. But if children are already undernourished, they are less likely to withstand the stress of an extreme event either in terms of their immediate response or their long-term development. Infants are at particular risk. Stresses related to a crisis may affect mothers' breast milk production; at the same time, breast-milk substitutes present a serious health risk in unsanitary environments (Caldwell, 1996; IFE Core Group, 2006). Malnutrition appears to be a greater risk among children of displaced families,[5] which may be related to the poor levels of sanitation in many temporary shelters as well as to the effects of displacement on household coping strategies.

Malaria and other tropical diseases: Warmer average temperatures are expanding the areas where many tropical diseases can occur, with children most often the victims (Bunyavanich et al., 2003; Ligon, 2006; Kovats and Akhtar, 2008). In many locations, the most serious threat is malaria. Up to half the world's population is now considered to be at risk, an increase of 10 per cent in the last decade (Breman et al., 2004). More than 90 per cent of the burden is in Africa, where 65 per cent of mortality is among children under five (Breman et al., 2004). Malaria also increases the severity of other diseases, thereby more than doubling overall mortality for young children (Snow et al., 2004). *There is growing evidence, too, of its impact for child development more generally.* This potential effect can result directly from the insult to the brain during acute episodes of malaria, but it can also be related to the effects of anaemia, repeated illness and the under-nutrition associated with the disease (Holding and Snow, 2001).

Heat stress: Along with the elderly, young children are at highest risk from heat stress: Children sweat less and have more surface area relative to body mass (Bytomski and Squire, 2003; Lam, 2007). Research in São Paulo found that for every degree increase above 20°C, there was a 2.6 per cent increase in overall mortality in children under 15 (the same increase as for those over 65) (Gouveia, 2003). Risks for younger children are even higher. Those in poor urban areas may be at highest risk because of the 'Urban Heat Island' effect, high levels of congestion and little open space and vegetation (Kovats and Akhtar, 2008). *Higher temperatures can also increase the risk of disease.* In Peru, for instance, over a six-year study, hospital admissions of young children for diarrhoea increased by 8 per cent with every degree centigrade increase above the normal average temperature (Checkley et al., 2000).

Injury: Injury rates are related to challenging conditions, overcrowding, chaotic environments and higher levels of preoccupation on the part of adults (Berger and Mohan, 1996)—all factors commonly experienced in the post-disaster period, as well as in the context of gradually worsening conditions. Children, because of their size and developmental immaturity, are particularly susceptible and are more likely to experience serious and long-term effects (for example, from burns, broken bones and head injuries) because of their size and physiological immaturity (Bartlett, 2002).

Quality of care: Despite their considerably greater vulnerability to a range of health hazards, with adequate care and support, young children can thrive even in difficult conditions. However, as conditions become more challenging to health, so do the burdens faced by caregivers, especially in groups where there are large concentrations of small children. These problems are seldom faced one at a time—risk factors generally exist in clusters. Overstretched and exhausted caregivers are more likely to leave children unsupervised and to cut corners in all the chores that are necessary for healthy living.

Children's learning and competence

For some children in some places, the added challenges brought about by climate change could contribute to an erosion of both their mental capacity and their opportunities for learning and growth. The early years are the most critical time for brain development, which can be shaped by a range of environmental factors (Wohlwill and Heft, 1987). Good health is crucial for cognitive development: Sick or malnourished children lack the energy to be active learners (Grantham-McGregor et al., 2007). Abundant research relates lower cognitive capacity and performance to under-nutrition, intestinal parasites, diarrhoeal diseases and malaria, as well as to maternal health and nutrition during pregnancy and maternal stress both during and after pregnancy.

Learning also depends on supportive social and physical environments and opportunities to master and build on new skills. Mental growth and development does not just happen to children; it is a feedback process that requires their active involvement (Walker et al., 2007). They need access to social interaction and to safe, varied and stimulating surroundings for play, which support their development as capable problem solvers and responsive social beings (Walker et al., 2007). When supportive environments and routines break down, so do opportunities for engagement and learning.

For older children and adolescents, opportunities for purposeful, goal-directed activities and engagement in the world are primary avenues for the achievement of competence.[6] When people are displaced, or when routines are disrupted, both formal and informal opportunities for learning can become constrained. After extreme weather events, for instance, schools may be destroyed, damaged, shut down or taken over as emergency shelters for weeks or even months.[7] Conditions for displaced children may also make it difficult to do homework, increasing the likelihood of dropout (INEE, 2004). Children may also be pulled out of school when households experience shocks; either the funds are not available or children are needed to help out the family.

At the same time, it should be recognized that numerous opportunities for learning and engagement exist within the context of adversity if children are given the space and support to be productively involved.

Coping with adversity

Much of the research and programming responding to the impact of extreme events for children have focused on their vulnerability to trauma. This approach has been criticized by many as a Western construct with questionable validity for other cultural realities (Batniji, et al., 2006; Boyden and Mann, 2005). As Engle and colleagues (1996) point out, the expectation of negative outcomes in these situations can unwittingly become part of the problem. Much of what is defined as symptomatic of pathology (such as bedwetting, regression to younger behaviour, anger or depression) may also be construed as a normal reaction to abnormal conditions. Frequently, it is the *aftermath* of a traumatic event and the deprivations and humiliations of a slow recovery process (rather than the initial event) that children and families themselves report as being the most stressful and debilitating (Becklund et al., 2005).

Levels of psychological vulnerability and resilience depend on numerous factors, including children's health and internal strengths, household dynamics and levels of social support, as well as the way experiences are perceived and interpreted (Boyden and Mann, 2005). Children who have experienced success and approval in their lives are more likely to adapt well to adversity than those who have suffered rejection and failure. Poverty and social status can have an adverse effect in this regard.

Without question, the losses, hardships and uncertainties surrounding stressful events can have high costs for children. Especially in low-income countries, children may end up orphaned or separated from family as a result of disaster. Extended family or other community members can provide a secure alternative, but even these bonds can be frayed to the breaking point, and extra children can become a target for mistreatment (Tolfree, 2005). Even when families remain intact, however, picking up the pieces can be extremely challenging. Basic requirements may be hard to obtain, livelihoods may have disappeared, relief may be inequitably distributed and community life and social supports may have collapsed.

Increased levels of irritability, withdrawal and family conflict are not unusual after extreme events (or even with gradually worsening conditions). Displacement and life in emergency or transitional housing have also been noted to lead to an erosion of the social controls that normally regulate behaviour within households and communities. Overcrowding, chaotic conditions, lack of privacy and the collapse of regular routines can contribute to anger, frustration and violence (Gururaja, 2000). In emergency camps, after the tsunami, adolescent girls, especially, reported sexual harassment and abuse (Fisher, 2005). High levels of stress for adults can have serious implications for children of all ages, contributing to neglect or to more punitive responses. Increased rates of child abuse have long been associated with such factors as parental depression, increased poverty, loss of property or a breakdown in social supports. For instance, in the six months after a hurricane in the United States, rates of inflicted head injury to children under two were found to have increased five-fold (Keenan et al., 2004).

The synergistic and cumulative effects of such physical and social stressors can affect children's development on all fronts. As the numbers of longer-term displaced people grow, and huge numbers of people are temporarily displaced on a regular basis by 'small' weather events, these dysfunctional environments can become the setting within which more and more children spend their early years. In one small settlement in Tamil Nadu, for instance, residents spend increasing amounts of time each year camped on a road near their settlement, waiting for water levels to recede to the point where they can re-enter and repair their mud-filled homes. In Kathmandu, Nepal, small children are routinely sent off to live with rural relatives during the monsoon each year, as water levels rise and sewage backs up into their riverside shanties. Older children and adults stay on, camped under plastic, unable to leave school or the jobs on which they depend.[8]

Even these less extreme events, seldom registered as 'disasters', can create havoc in families' lives. Repeated adversity can result in a significant loss of assets, reducing the capacity to prepare for and adapt to other events and deepening poverty to a level beyond which many households can reasonably cope. When this happens, children may feel the brunt of it. Recent research from Bangladesh, for instance, shows that when there are not enough calories available within a household to meet the requirements of all members, children are the most likely to be short-changed (Cockburn et al., forthcoming). During hard times, children can become an asset that is drawn on to maintain the stability of the household (Mitik and DeKaluwe, forthcoming). They may be pulled from school to work or take care of siblings. Some children may be considered more 'expendable' than others (Engle et al., 1996). Many of Mumbai's young prostitutes are from poor rural villages in Nepal, where inadequate crop yields lead families to sacrifice one child so others may survive.[9]

Again, though, it is misleading to think of children simply as victims and not to appreciate the level of emotional resilience and competency that they can bring to adversity. There are numerous accounts of their hardiness and resourcefulness in the face of both extreme events and everyday difficulties (Hestyanti, 2006; Boyden, 2003). Children may, in fact, be more flexible than adults in their capacity to adapt to extreme situations. It is easy to forget that many children, even in 'normal' times, function competently in adult roles, running households, caring for younger children, handling jobs and negotiating a variety of complex realities. This level of responsibility may be less than ideal for children, but this should not diminish the respect they deserve for their capacity to manage challenging conditions. Children's capacity to cope well in very difficult situations has been attributed to their own active engagement, opportunities for problem solving and for interactions with peers (Boyden and Mann, 2005), as well as to the presence of at least one consistently supportive adult in their lives (Engle et al., 1996; Werner and Smith, 1992).

Implications for Adaptation

In seeking to reduce vulnerability and enhance resilience in the face of the various hazards and risks associated with climate change, how can the many concerns for children of different ages be adequately addressed without completely overwhelming any agenda?

In every aspect of adaptation—protection, preparation, relief and rebuilding—and at every level of response (community, local government, non-governmental organizations [NGOs], international agencies, etc.), some basic concerns need to be taken into account in order to respond effectively to children. These responses must be based on an adequate knowledge of children's lives and experiences and the challenges faced by their caregivers, and the concerns must be integrated into planning, decision-making and action, not treated as add-ons after the fact. It is critical, among other things, to recognize the implications of the actual numbers of children in different age groups in any population. In places with very large numbers of young children relative to caregivers and other adults, the ability of the community to provide adequate care in the context of unusual adversity may be underestimated. Conversely, where responses are expected to involve the active participation of community members, there may also not be an understanding of the conflicting responsibilities of many adults. On the other hand, older children can play a real role in effective adaptation efforts, and this should be thoughtfully capitalized on.

Measures should include:

- *Ensuring children's optimal health and nutrition:* Ensuring children's health through adequate nutrition, preventive care and environmental health measures is a potent form of risk reduction. The overall impact of an event will be defined in part by children's pre-existing levels of health—and there are implications for both the urgency and the effectiveness of responses. Food aid and supports for health are vital after crises, but when health is already compromised by malnutrition or illness, children are more likely to suffer long-term damage from extreme events and worsening conditions and also to be a drain on families' capacity to cope. Where extreme events or food shortages are likely, longer-term nutritional and health programmes are critical protection and preparation measures and are more effective than humanitarian aid after the fact for children's long term recovery and well-being. A concern for children's health is also a compelling additional reason for local governments to tackle environmental sanitation problems in underserved areas as part of their preparation for extreme events.

- *Strengthening families' capacity to cope:* All adaptive measures should ideally enhance the capacity of households to come through periods of shock with minimal upheaval. But supporting family coping strategies takes on broader meaning when children are an explicit part of the equation. There should be a focus on the capacity of families to manage hardship without compromising the well-being of their children and a recognition of the time that may be necessary to respond to what may be intensified needs on the part of children. NGOs, for example, might build child-impact assessments into their microcredit activities, ensuring that loan repayments do not compromise children's nutrition; a health-care system might allocate more of its resources to mental health supports; emergency response planning could include the provision of temporary child care, so that parents can have some hours each day to focus on recovery without worrying about their young children.

- *Maintaining, restoring and enriching children's routines, networks and activities:* Children rely on their daily routines and activities for stability and optimal development. Other functions, more critical to survival, will inevitably be prioritized in extreme situations (food, health, livelihoods). But in the course of addressing these, it is important not to compromise children's spaces, activities, networks and opportunities for gaining competence (for instance, by ensuring wherever possible that emergency camps not be set up for months at a time in schools and that safe spaces for play be a priority even right after extreme events.) Mann (2000) has pointed out that restoring a sense of normalcy for children also extends to reinstating the chores they are accustomed to perform, so that their sense of pride and self-respect remains intact.

- *Respecting children's capacities; supporting their active involvement:* On a related front, the chance to solve problems, contribute and take action is known to be a potent protective force for children in adversity. Repeated experience also demonstrates how capable children are of looking critically at local problems and coming up with creative solutions that may not have occurred to adults (Hart, 1997; Chawla, 2001). Every day, in communities around the world, children and adolescents do their share to keep their households afloat and functioning. Many observers are critical of children's involvement in activities that may affect the time they can give to school and study. Certainly there is the potential for undermining education and even for serious exploitation. But the fact is that, for many children, balancing the demands of school with help for the family stimulates their self-reliance, self-respect and overall capacities (Boyden, forthcoming). The contribution of children and young people is also a potential community asset that is too seldom tapped in the formal process of development and adaptation. There are numerous precedents for effective action in disaster risk reduction, preparedness and rebuilding. In the course of local risk assessment and monitoring, for instance, children's extensive knowledge of their own neighbourhoods can be invaluable; children can also be involved along with adults in critiquing and modifying plans for relocated housing and community space, since they inevitably point to concerns that adults overlook (Bartlett and Iltus, 2007).

Conclusions

There are many vulnerable populations in the context of climate change—the poor, the elderly, pregnant women, those in particularly hazardous locations. Children are not unique in this respect. However, they constitute an extremely large percentage of those who are most vulnerable, and the implications, especially for the youngest children, can be long term. If responses to the impacts of climate change fail to take into account the particular vulnerabilities (as well as capacities) of children at different ages, measures for prevention and adaptation may prove to be inadequate in critical ways and may even result in additional stresses for young minds and bodies.

Addressing these concerns for children may appear to be an unrealistic burden, adding unduly to the need for time and resources in the face of so many other compelling priorities. Fortunately, there are strong synergies between what children need and the adaptations required to reduce or respond to more general risks. For instance, the most useful measures to protect children's health—such as adequate drainage, waste removal and proper sanitation—are also fundamental in reducing risks from potential disasters. Providing support to adults so that they are better able to address their children's needs leaves them better equipped to work collaboratively on reducing risks, preparing for disasters and rebuilding their lives after a crisis. Ensuring that children continue to have opportunities to play, learn and take an active role in finding solutions will prepare them to be citizens who can continue to address the problems faced by their communities and by the planet. It has generally been found that neighbourhoods and cities that work better for children also tend to work better for everyone else, and this principle undoubtedly applies to the adaptations that are necessitated by climate change as well.

Notes

1 It is worth noting that most of the locations that currently face the most extreme weather events (e.g., in regard to cyclones/hurricanes/typhoons, heat waves, heavy rainfall and droughts) are in low- and middle-income nations; also, a high proportion of the world's population within the low elevation coastal zone are in those countries.

2 Population figures and projections are drawn primarily from PRB, 2008.

3 See, for instance: Evans and English, 2002; also see: Werner and Smith, 1992, for classic research exploring resilience longitudinally in a cohort of children in Hawaii.

4 See, for instance: Moraes et al., 2003.

5 See, for instance: Jayatissa et al., 2006; and Barrios et al., 2000.

6 See for instance: Chawla and Heft, 2002.

7 See, for instance: Diagne, 2007.

8 Author's personal communications with residents in Tamil Nadu and Kathmandu.

9 See website: http://www.speakout.org.za/about/child/child_childprostitution.htm, last accessed 5 September 2009.

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9

Gender and Climate Change Policy

Gotelind Alber

Introduction

This chapter describes how the various aspects of discrimination against women are linked to climate change, in relation to both adaptation and mitigation. Based on a rapid assessment of the flaws of international climate policy in terms of gender, guidelines are provided on how to address the gender dimension.

It is widely accepted that women are among the groups most vulnerable to the impacts of climate change. After years of ignoring gender issues, talking about 'systems' rather than people[1] and about power plants rather than consumption, the international climate negotiations are now starting to take up this issue. In the current negotiating text of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA) women are mentioned several times, for example:

> *In providing support, priority [shall] [should] be given to: . . . Particularly vulnerable populations, groups and communities, especially the poor, women, children, the elderly, indigenous peoples, minorities and those suffering from disability* (UNFCCC, 2009b, p. 53).

However, if the underlying reasons for women's (and men's) specific vulnerabilities are not analysed and addressed properly, the results will be merely rhetorical. For a rough overview, the main factors and forms of discrimination against women are given below. The specific vulnerabilities of men are not included, since these still need to be better analysed.

Gender Inequality and Vulnerability to the Impacts of Climate Change

One of the main factors of gender inequality is the *gender division of labour.* A disproportionate share of unpaid care work and other unpaid labour falls on women. Time-use studies show that, in all countries, women spend considerably more time in unpaid work than do men. In rural India, for example, women's unpaid work amounts to more than 36 hours and their paid work some nine hours a week, while men spend 41 hours for paid work and only three-and-a-half hours for unpaid labour (Central Statistical Organisation of India, 2000). In developing countries, a considerable part of women's unpaid work revolves around natural resources: collecting fuel and water, subsistence agriculture and gathering food and fodder in forests. In South Africa today, for instance, many women spend two hours to collect fuel and about one hour to collect water (Statistics South Africa, 2001). As climate change reduces crop yields and the availability of wood and increases water scarcity, these natural resource-dependent activities will be severely affected.

Even if women have a full-time job—even in forerunner countries in gender equality such as Sweden—the extra time women spend on unpaid domestic work is several hours per week. The ratio between unpaid and paid labour for Swedish women is 1.15, while for men it is 0.56 (Statistics Sweden, 2008).

The impacts of climate change are likely to increase the unpaid work burden of women, due, for example, to longer walking distances to collect water and fuelwood, additional care for the sick and elderly and food insecurity.[2] These tasks are likely to be carried out at the expense of education or income-generating activities. Smallholders are affected the most in relative terms. Many of these women do not have alternatives for income generation, and, with increases in food prices and declines in subsistence production, food insecurity may lead to precarious situations. Moreover, many women, in particular those in female-headed households, cannot avoid the impacts because of their family responsibilities.

It should be noted that the gender division of labour leads to constraints for women in industrialized countries, as well, at least to a certain degree. For example, the time required for family care may increase worldwide with greater climate variability, since the sick and elderly will need more care.

Another underlying reason for women's higher vulnerability is the *difference in incomes and economic resources for women and men.* Though repeatedly cited, the statement that "70 per cent of the world's poor are women" must be considered a myth, for no evidence has yet been provided (see, e.g., Chant, 2006). However, it is indisputable that the proportion of women among the poor is substantially higher than for men and, in general, that women's level of wealth is dramatically lower. The expansion of female-headed households, a trend in both industrialized and developing countries, may add to the 'feminization of poverty', while, for others, the uneven distribution of income within the household, due to imbalances in power relationships, might lead to hidden forms of female poverty (Chant, 2006).

A major factor is the pay gap that exists all over the world in varying degrees. Women are paid less for the same work, and this gap seems to be persisting. In Australia, for example, the ratio of female to male income started to level out during the 1980s, but, during the 1990s, the ratio fell again until it reached early 1980 levels (Stilwell and Argyrous, 2002).

In addition, the gender segregation in occupations leads to lower incomes for women who usually work in jobs that are less valued and lower salaried, for instance, in the service and care sectors. Recent data from the European Commission, for example, show that young women still tend to choose these 'female' occupations, while their share of engineering, manufacturing and construction jobs is less than 25 per cent (Statistisches Bundesamt, 2009). Consequently, women will benefit less from job opportunities created through investments in renewable energy, one of the main pillars of many countries' mitigation strategies.

Even more worrying in terms of vulnerability is the huge gender gap in assets, including financial assets, land and real property. One of the underlying reasons for this gap is the insecurity over, or even the denial of, land and inheritance rights, whether this is based on formal legal restrictions or customary rights or the lack of enforcement of legal provisions for equality. For example, in Pakistan, in 2001, women owned less than 3 per cent of the plots, even though, in most cases, legal regulations allowed them to own land (ICRW, 2005). With respect to other assets:

> *Women are less likely than men to own almost every type of asset. The median value of assets held by women is almost always lower than that of their male counterparts. A smaller percent of women own stocks, bonds, and other financial assets compared to men. Women are also less likely to hold retirement accounts and a woman's pension is typically smaller than a man's* (Jaggar, 2008).

Furthermore, women's access to markets and credit is limited. According to an analysis of some countries, they received less than 10 per cent of loans of male smallholders (FAO, 2001).

As a consequence, due to their paucity of resources, women have fewer options for coping with or avoiding the impacts of climate change. Again, this holds true for women in both developing and industrialized countries. However, for women in the Global South, situations that threaten survival are more likely to occur. Moreover, their informal rights to resources could disappear in times of scarcer land resources as there is likely to be increased competition over the control of land.

A third factor is *differences in power* and the lack of representation and participation of women in public and private decision-making bodies. In national parliaments, less than 20 per cent of the members are women (PARLINE, 2009), and, in national governments, the picture is similar. For instance, in countries of the European Union (EU), 26 per cent of senior ministers are women (European Commission, 2009). Even in Sweden, the share of women among legislators, senior officials and managers is only about one third. At the local level, contrary to common opinion, the situation is no better, as the bias is in a similar range: Only some 20 per cent of city councillors and less than 10 per cent of mayors are female.[3] In most fields, even if they hold a majority of the jobs, as they do in education, the air gets thinner for women at higher levels of the hierarchy. For example, in Europe, less than one third of business leaders are female, while in the highest decision-making bodies of the largest companies, the share goes down to about 10 per cent (European Commission, 2009). In energy companies, a core area for climate change policies, the percentage of women tends to be even lower, with, for instance, a proportion of 4 per cent at the executive level in Germany.

It is therefore not surprising that women are also underrepresented among delegates of Parties attending the United Nations climate sessions. During the last years, their share varied between 25 and 30 per cent, while women's proportion among heads of delegations was substantially lower with a quite large fluctuation (GenderCC, 2009a). As for non-governmental organizations (NGOs), the gender balance seems to be less skewed (except for those of business groups), as can be seen, for example, from the number of postings in relevant list services (see: Eyzaguirre, 2007). Currently, efforts are being made among environmental NGOs to establish an equitable gender balance in working groups and committees.

Would the outcome be different if more women were involved? There are some indications that other, and more ambitious, policies would receive increased attention, for example, a massive increase in renewable energy sources and far-reaching, strong measures to reduce over-consumption. In particular, there is evidence from surveys in various countries that women are less willing than men to accept risky technologies such as nuclear power and ocean fertilization.[4] When it comes to implementing climate policy at the community level, it is incontestable that the increased involvement of women would help to better take their specific vulnerabilities, and that of their entire families, into consideration.[5]

Other consequences of *cultural patterns and social roles* which discriminate against women largely vary from country to country and include constraints on access to information and education and restrictions on personal, social and economic activities outside the home. It has been repeatedly reported that early warnings,— for example, flood warnings in Bangladesh,— have not reached women or have not been understood by them. Moreover, both during and, in particular, after disasters, women are exposed to sexual harassment and violence, especially young women and girls, and especially in temporary shelters and refugee camps. Although some cultural patterns lead to higher risks for men, such as expectations of heroism—for instance, in the aftermath of Hurricane Mitch in Central America—in most cases, women might be more at risk, and there is heavily cited evidence that women are subject to more fatalities during floods, heat waves and post-disaster difficulties. Based on an analysis of some 4,600 natural disasters over a 20-year time span, Neumayer et al. (2007) provided evidence for a stronger decrease in the life expectancy of women than that of men due to these disasters. Biological differences could not explain the gender gap; rather the socio-economic status of women and social norms related to gender were found to be decisive factors.

However, in addition to gender-related causes, sex-related factors stemming from biological differences add to greater vulnerability. These include reproductive health issues, for instance, the need for sanitation during menstruation and after giving birth, constrained mobility during pregnancy and higher nutritional needs during lactation. Women seem to be more sensitive to heat stress, and this was a factor leading to a higher mortality for women during the 2003 heat wave in Europe, with the highest mortality rate among elderly women (Pirard et al., 2005).

Eventually, the cumulative impact of these factors—gender divisions of labour, income inequalities, power relations and culturally specific gender norms and roles—will result in a larger number of women severely affected by the impacts of climate change and in a greater vulnerability for individual women and fewer options and capacities to cope with climate variability. Secondary effects might be seen in specific patterns of migration, for example, male out-migration, leaving women and the rest of their families behind in an even more precarious situation. In the long run, due to the increased work burden of women for family care and livelihoods, they may have even less time for involvement and participation in community affairs, and girls may suffer from lower school enrolment and reduced educational opportunities, thus consolidating and aggravating the discrimination against women. As stated in the *Human Development Report 2007/2008:*

> *The trade-offs forced upon people by climate shocks reinforce and perpetuate wider inequalities based on income, gender and other disparities* (UNDP, 2007, p. 86).

Gender and Adaptation to Climate Change

Some of these factors have now been acknowledged in international negotiations, though not necessarily to their full extent. Responses and remedies, however, are still in their infancy, and gender is far from being addressed properly and specifically. This can be seen in the the National Adaptation Programmes of Action (NAPAs) that the least-developed countries (LDCs) are required to set up in order to identify priority activities and receive funding.

NAPAs are expected to organize a national and/or subnational consultative process, guided, among other principles, by sustainable development and gender equality (UNFCCC, 2002, p. 9). However, no further guidance is given on how to operationalize these criteria, for instance, by providing methodologies for vulnerability assessments that are suited to detect gender bias and gender-specific vulnerabilities.

A quick scan of available NAPAs (UNFCCC, 2009a) reveals that gender issues are not explicitly addressed and included when it comes to prioritizing adaptation projects. 'Gender' is mainly understood as the participation of ministries in charge of equal opportunity or women's organizations in the consultations, however, without holding separate consultations with women. Only Tuvalu was striving for a better overall gender balance. Consultations were held at various levels and efforts were made in selecting participants and in monitoring to achieve a balanced representation.

A number of countries have included gender equality or women's empowerment into their list of criteria, and, in some plans (the Bangladesh, Guinea-Bissau, Lesotho, Malawi, Niger and Uganda NAPAs), women were identified as the most vulnerable group. While most countries held consultations at the national level, only Samoa used a method to identify vulnerability at the community level, applying the "Community Vulnerability and Adaptation Tool" (Samoa, 2005, p. 62).

Among other stakeholders, women's councils or women's committees and youth groups were involved in the workshops.

In most NAPA processes, however, gender was hardly mentioned during the elaboration and prioritization of projects, and only a very few projects were left that specifically addressed women's concerns. For instance, in the Burundi NAPA, women's empowerment rated low among various other criteria, such as sustainable environmental management, cost, capacity for adaptation and fighting poverty. In other countries, projects that survived the selection process included a specific action for female-headed households among a package of other action measures (Eritrea; the number of female-headed households is reported to amount to 30 per cent in some areas); empowerment of women through access to microfinance in order to diversify earning potential (Malawi); and sensitization and awareness-raising campaigns on climate-change impacts on women related to the three conventions on biodiversity, desertification and the United Nations Framework Convention on Climate Change (UNFCCC) (Sierra Leone).

Of course, women will benefit from many of the projects, but it appears that NAPAs fail to address both gender aspects as a whole and the specific vulnerabilities of women in a comprehensive way. Bangladesh, in its NAPA, has ranked "poverty reduction and security of livelihoods with a gender perspective . . . as the most important set of criteria for prioritization of adaptation needs and activities" (Government of Bangladesh, 2005). However, gender experts point out that there is neither a gender concern in the programmes prioritized in the NAPA, nor is there an analysis of the differential vulnerability in the National Climate Change Action Strategy undertaken by the Government (Neelormi, 2009). The examples provided by Neelormi (2009) demonstrate that there is a wealth of measures that would respond to women's and girls' specific vulnerabilities and, moreover, would benefit men and boys, too (see Box 9.1). Although these can be simple, straightforward measures, they do not receive proper attention, simply because men do not suffer to the degree that women do, for example, from a lack of proper sanitation facilities.

In the meantime, the Climate Change Cell, under the Department of Environment, Ministry of Forest and Environment, commissioned a team to carry out a study on gender and climate change in Bangladesh (Ahmed et al., 2007). It is still unknown to what degree the Government will incorporate the findings into their strategy.

Furthermore, Neelormi (2009) identifies the most relevant policies and documents with the potential to address climate change in Bangladesh, all of which would need to undergo a gender analysis in order to incorporate the gender dimension: National Water Policy, National Strategy for Economic Growth and Poverty Reduction, Standing Orders on Disasters, Environmental Policy and Implementation Programme, National Agriculture Policy, National Seed Policy, National Land-Use Policy, National Forest Policy, National Fish Policy, National Policy for Safe Water Supply and Sanitation 1998, Coastal Zone Policy and National Tourism Policy.

Box 9.1: What Needs to be Done on the Ground to Address Gender Concerns Properly?

The Case of Cyclones

Concerns related to the women:

- Economic and social insecurity due to the destruction of houses;
- Food insecurity because of damaged crops and loss of livestock;
- Higher death rate for women, because many do not use cyclone shelters since they do not provide security for women, the stairs are too high for women with children, sanitation is inadequate;
- Warning information is not disseminated in a timely manner to women, and most women are unaware of the meanings of different warning signals.

Measures to be taken for adaptation:

- Adequate number of cyclone shelters to be provided, especially in cyclone-prone areas;
- Strengthening of security in the cyclone centres;
- Major improvement of sanitation systems in the cyclone shelters;
- Women should be made to understand the warning system, and timely dissemination is also necessary;
- Government should rehabilitate the actual victims by creating employment opportunities and by helping in reconstruction efforts.

National policy:

- The National Five-Year Strategic Plan for the Comprehensive Disaster Management Programme (2004-2008) envisages bringing a paradigm shift in disaster management from conventional response and relief practices to a more comprehensive, risk-reduction culture. The plan incorporates programmes to strengthen the capacity of the Bangladesh disaster management system in order to reduce unacceptable risk and improve response and recovery management at all levels.

Barriers to policy implementation:

- The main barrier is lack of governance: Corruption, defective administrative structures, lack of accountability and transparency are the root-level constraints of policy implementation.

Recommended response measures:

- Improvement in the management of cyclone shelters;
- Increase in the number of cyclone shelters according to population;
- Timely dissemination of information about cyclones to women through effective media;
- Supply adequate tools for early warning;
- Strengthen local-level capacity in handling massive cyclones;
- Raise awareness about the entire community's right to shelter.

Source: Abridged extract from Neelormi, 2009. Note: Similar analyses for the other most important hazards in Bangladesh (drought, flood, salinity, flash flooding and water logging) are provided in this briefing paper.

It is obvious that an integrated climate policy, addressing both adaptation and mitigation, would be even broader in its cross-cutting character. Here, the main challenge of gendering climate policy is becoming apparent: Both gender issues and climate change require mainstreaming, and, consequently, 'double-mainstreaming' is needed to integrate climate into all relevant sector policies and day-to-day administrative procedures, while simultaneously integrating gender aspects at all stages.

Squaring the Mainstreaming Circle

Has mainstreaming worked so far? Gender mainstreaming—understood as integrating equality between women and men into all policies and activities and into every stage of policymaking—was adopted in 1996 as official European Commission policy to promote equality between women and men[6] shortly after the Beijing Platform for Action introduced gender mainstreaming. Whereas the mainstreaming approach is working fairly well for social policies, it is actually not fully implemented in the Commission's research activities and policies, and it is completely absent in environment and energy policies. This does not come as a surprise, since these are policy areas where the gender aspects are not often obvious and thus need careful analysis. Women are under-represented in these areas, anyway, making things even worse if the gender aspects are not explored.

As for the climate policy of industrialized countries, the response to the current economic crisis demonstrates that mainstreaming of climate considerations has not been achieved at all. Counterproductive subsidies benefiting harmful fossil fuel industries and the call for massive economic growth to counterbalance increasing national debts are mushrooming. The vast potential for emissions reductions from energy efficiency, which would require consideration of climate issues for any investment, still remains untapped.

International climate policy has not even given a signal that mainstreaming efforts would be more useful than merely relying on singular projects, either for climate policy itself or for gendering it. It is difficult to anticipate whether the fact that climate policies are not yet fully established will make them more open to the inclusion of gender issues, or if an effort of double mainstreaming would end up in an attempt to square the circle. In any case, first steps at the international level are urgently required: to acknowledge the need for mainstreaming, draw from national and even local experience and build capacity on gender and climate mainstreaming.

Making Use of What is Already There

There is a wealth of proven and tested methods and tools to address gender issues that are either suited for or can be adapted to climate policy. For instance, the Gender and Disaster Network (GDN) has developed "Gender Equality in Disasters: Six Principles for Engendered Relief and Reconstruction" (2009), which highlights, inter alia, that gender analysis is imperative and that actions must rely on women in grassroots organizations, building on their capacities and knowledge of the specific contexts, without, however, increasing their work burden. The observation of such rules, and the application of the related methods and tools offered by GDN and other networks, such as the Gender and Water Alliance,[7] would make the oft-quoted slogan "women are powerful agents of change" a reality. This would also build on the existing coping strategies of women to address climate variability and disaster, by, for example, switching to drought resistant crops, using traditional medicine and health care and organizing collective action. Methods and tools are available from development policy or other policy fields that can easily be adapted to suit climate policy purposes, such as Gender Impact Assessments and Gender Budgeting.

An interesting tool for a Gender Impact Assessment of transport has been proposed by Spitzner et al. (2007) (see Box 9.2). It is unique in its far-reaching approach, addressing both the above-mentioned factors of discrimination and the deeply rooted underlying causes such as androcentrism and symbolic order, thus contributing to bringing about more in-depth change. It can easily be translated to sectors other than transport and can in principle be used for policies and other measures, as well.

A further important field of action in terms of gender is women's access to information, education and capacity building. Article 6 of the UNFCCC (United Nations, 1992) covers this, requiring parties to promote and facilitate public awareness and participation, education and training. Although this is a key area for both adaptation and mitigation, the efforts under Article 6 play only a minor role in the international process and have not yet been gendered. Such activities are first steps, providing entry points to reducing vulnerability, and are a prerequisite for meaningful contributions.

Reaching women and men requires awareness of their different roles, attitudes, preferences and skills. There are no neutral means of communication, since neglecting gender differences might lead to exclusion or at least to less effective communication. Therefore, outreach and other activities related to Article 6 require awareness on gender and diversity and need to include gender (and social) differences in all phases of planning and implementation.

Gender-sensitive communication refers to the contents and topics that are to be transmitted, and whether they meet the needs of women and men, taking into account, for example, differences in education or even illiteracy. Moreover, it needs appropriate media and communications channels and gender-sensitive and inclusive language and design. Eventually, it should also contribute to overcoming the limitations of gender roles and to avoiding gender stereotypes.

However, as yet all these rules, guidelines, resources and tools seem to be unknown by climate policymakers. GenderCC is seeking to address this gap and is currently preparing a "Toolkit for Decision-Makers" that is intended to shed light on existing methodologies that are useful for exploring, and addressing, the gender dimension of adaptation, mitigation and financing (GenderCC, 2009b). But more needs to be done to bring gender from rhetoric to implementation, for

Box 9.2: Dimensions of the Gender Impact Analysis for Transport Projects (brief version)

1. Care economy: Does the project take a balanced view, compared with other economic sectors, of the mobility requirements of the care economy, for which women, because of the role assigned to them, bear a disproportionately large share of responsibility (while too little responsibility is borne by men), for example, by reducing the time taken, time horizons, physical and social appropriateness of transport between the home and place of work and everyday shopping facilities, the location of the workplace, self-determined social contacts, family members, schools, medical health centres, etc., and not place too much importance on the traffic requirements of the work economy, which is the main concern of men (transport between the home as a place that is free from work and places of gainful employment, business commuters)?

2. Resources: Do the financial resources and measures of a project benefit women to the same extent as men? Does the project lead to a more balanced distribution of public space and public money between men and women? Is economic development required which takes as much account of the interests and priorities of women as of those of men?

3. Androcentrism: Does the project promote the view in institutions and situations relevant to the decision-making process that male lifestyles and ways of thinking are central and the norm while women's lifestyles and thought patterns are seen as a deviation and hence as 'other', 'specific' and 'an exception to the rule'? Does the project support the need to revise previous generalizations of the male perspective and their claim to 'objectivity' or 'general usefulness' or contribute to their institutional enshrinement (revision/adjustment of conventional methods, definitions, procedures, criteria, etc.)?

4. Gender composition: To what extent does the project contribute to giving women and gender-mainstreaming representatives greater influence in the design, planning and decision-making processes? What contribution does the project make to increasing the share of women and gender-mainstreaming issues in important positions?

5. Symbolic order: Does the project create or reinforce symbols which enhance the importance of women or do pejorative symbols weaken or undermine it completely? Does the project stabilize a gender-biased allocation of duties or rights or does it promote individualization opportunities for women and men sharing the duties?

6. Harassment: Does the project contribute to reducing male harassment and the exploitation of women? Does it contribute to making this the object of political, public, infrastructural or entrepreneurial problem solving? Does it contribute to relieving women of threats, restrictions and sanctions?

Source: Adapted from Spitzner, 2007.

example, a workshop within the official United Nations climate agenda that deals with the implementation of gender mainstreaming in climate policy. In any case, these efforts should not be narrowed down to adaptation; they need to cover all issues under debate.

Gender and Mitigation

As for core issues of the climate negotiations other than adaptation—mitigation, technology transfer and financing—the gender dimension is completely absent. However, gender roles and division of labour, access to and control over resources as well as gendered attitudes and consumption patterns are also very likely to play a role in mitigation. A few examples to illustrate the gender and mitigation link follow.

Even the causes of climate change have a gender dimension. Since emissions are linked to consumption, and men's higher incomes allow for more consumption, it is plausible to come to the conclusion that greenhouse gas emissions generated by men might be higher. A detailed study showed that this estimation is true for one-person households in European countries, regardless of age, social status and absolute income levels. The carbon footprint of men, calculated from their expenditures in different consumption categories, was significantly higher than that of women, primarily because of car use (Carlsson-Kanyama and Räty, 2008).

It is particularly in the transport sector that gender differences are the most visible, be it the preferences when purchasing a vehicle—in Germany, men pay attention to comfort, design, technical innovations and branding, and women to costs, fuel consumption and environmental acceptability—or be it the intensity of car use or the disposition to switch to less carbon-intensive transport modes (BMU, 2007, 2008; LeasePlan 2008). Moreover, the care work done by women has impacts on their mobility patterns, creating the need for gender-sensitive transport planning (see Box 9.2).

If climate policy is focusing on fiscal instruments such as taxation and emissions trading, both eventually leading to higher energy prices, economically disadvantaged groups are penalized, directly and also indirectly since most of them, as tenants, have less options to save energy than house owners. Today already, energy costs make up a disproportionally high share of poor households' expenditures since they often live in rented apartments lacking reasonable energy efficiency standards.

Significant gender differences in attitudes towards climate policies and measures can be observed in many countries.[8] In general, women are more concerned about the environment and about climate change which fits very well into their greater risk awareness, and they tend to favour changes in consumption patterns and life styles rather than technological approaches.

Not only climate policies and measures, but also their impacts may involve gender aspects. For example, in the businesses that benefit from climate policy, such as construction and the production and installation of low-carbon technologies, women hold a minority of jobs. In Germany, where renewable energy sources are a booming sector due to the favourable national policy framework, the average percentage of female workers in renewable energy companies is some 25 per cent, and, in vocational training, it is only slightly higher (Wissenschaftsladen Bonn, 2007). Among energy advisers, women's share is less than 20 per cent. On top of the gender bias in job opportunities, this underrepresentation might lead to a neglect of women's needs for adequate information, and will in any case constrain their participation in decision-making and implementation in the energy sector.

From these brief examples, it can be concluded that gender mainstreaming and the application of adequate instruments for analysis and participation should be a part of mitigation policies and measures, as well as those for adaptation. This could, for instance, in some cases mean that regulation would be preferred to market-based instruments, in order to avoid disadvantages for women due to their lower incomes and limited access to markets.

Conclusions

It should be noted that improving the participation of women in climate policy and the endorsement of the strategy of gender mainstreaming would only be a first step in integrating gender equality issues. In order to achieve gender justice within climate justice, societal structures and patterns that perpetuate injustices have to be addressed. As noted:

> *[t]he challenges of climate change and gender injustice resemble each other—they require whole system change: not just gender mainstreaming but transforming gender relations and societal structures. Not just technical amendments to reduce emissions, but real mitigation through awareness and change of unsustainable life-styles and the current ideology and practice of unlimited economic growth. Not the perpetuation of the current division of resources and labour but a responsible cooperative approach to achieving sustainable and equitable societies* (LIFE and GenderCC, 2009).

Finally, the question is how all this is related to population issues, except for the fact that "babies come from ladies."[9] Two main lines of argument are put forward to support addressing these issues in international climate policy: First, it is evident that emissions will inevitably rise with the growing population. However, the size of the effect is disputed as population growth in the developing world is occurring primarily in countries with very low per capita emissions. Second, there is a large unmet need for family planning (WHO, 2009), and some advocates hope to revive the attention of donors if this is connected to climate change.

But as long as industrialized nations do not demonstrate that they are willing and capable of achieving deep emissions cuts, initiating a discussion on population within the international climate negotiations seems to be neither adequate from an ethical point of view, nor wise from a tactical perspective. Moreover, in consideration of the performance of the mechanisms under the Kyoto Protocol, the prospect of climate policymakers' designing a population control mechanism would simply be frightening. After all, due to its character of causes and impacts, climate change is linked to nearly every policy domain. However, this does not necessarily mean that there is a primacy of climate policy in the sense that all other policy fields should be subsumed and addressed under climate policy. Instead, sustainable development, including aspects of well-being and welfare, equity and justice, is still the overarching issue.

Notes

1 See, for example, the Intergovernmental Panel on Climate Change's (IPCCs) definition of vulnerability in the Third Assessment Report (IPCC, 2001):

> *Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (2001, p. 6).*

2 See, for instance, the article by F. Denton (2002) in Oxfam's journal, *Gender, Development and Climate Change*, which was one of the first publications to present gender and climate change to a wider audience.

3 See the website of United Cities and Local Governments: http://www.cities-localgovernments.org, accessed 1 September 2009.

4 See, for example: Finucane et al., 2000; Kiljunen, 2008; European Commission, 2007; and BMU, 2008.

5 See, for example: Chattopadhyay et al. (2004), who present evidence for the different priorities of local female policymakers compared to mainstream male-dominated policies.

6 See the European Commission website: http://ec.europa.eu/social/main.jsp?catId=421&langId=en, accessed 7 October 2009.

7 See the GWA website: www.genderandwater.org, last accessed 4 October 2009.

8 See, for example: BMU, 2008.

9 *Faith and hope and charity / one for you and one for me / money doesn't grow on trees / but babies come from ladies* (Fun Boy Three, 1982). This might sound flippant, but it does point out the common notion that population issues are primarily women's issues. Women's needs are for access to reproductive health and contraceptives, but these should not be mingled with population issues.

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10

Population, Climate and Health

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Introduction

Global climate change will have important implications for human population health. It is one of the emerging set of global environmental changes that are already affecting human population health and will increasingly do so in the future (ESSP, 2006). Climate change does not exist as a separate, single exposure, but consists of a range of exposures that are relevant for human health (McMichael et al., 2006). Climate change will exacerbate many of the current important environmental determinants of disease. Some climate and weather factors act directly and are relatively well understood—such as the health effects of heat waves or the physical and mental consequences of floods. Other health effects are mediated by climate-sensitive biological processes, such as changes in infectious disease transmission or crop yields. Climate is ultimately the determinant of food and water availability and the distribution of vector-borne diseases. Climate-related decreases in food and water supplies are potentially responsible for the largest future burden of disease due to climate change (Campbell-Lendrum and Woodruff, 2006). But such impacts are also the most uncertain to foresee because they are contingent on future social, economic, political and population factors.

There is now a wealth of evidence regarding changes in climate and environment due to anthropogenic climate change. The Intergovernmental Panel on Climate Change (IPCC) published its Fourth Assessment Report in 2007, which included a global assessment on the impacts of climate change on human health (Confalonieri et al., 2007). The conclusion of the health chapter was that:

> *. . . the health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased diseases due to higher concentrations of ground-level ozone related to climate change; and the altered spatial distribution of some infectious diseases* (IPCC, 2007).

The scientific evidence base it still evolving. Currently, the main evidence for the impacts of climate change is based on large-scale modelling of bio-geophysical systems. There has been a lack of evidence about the effects on human systems and how population and environmental factors interact to increase the burden of disease.

Evidence for current sensitivities of a population's health to weather and climate is based on epidemiological studies. The current state of knowledge on the health effects of weather and climate variability from epidemiological studies is summarized in Table 10.1. There is a need to infer the potential health effects from current and past climate variability in order to account for the greater spatial and temporal scales appropriate to climate change. Such analogue studies are useful for investigating the impact of larger-scale climate effects on health by looking at past climate events, such as droughts. An example is the demonstrated effects of the global climate phenomenon the El Nino-Southern Oscillation (ENSO) on malaria (Kovats et al., 2003).

For assessing the future impacts of climate change, a range of health-impact models need to be developed for specific diseases (e.g., malaria) and environmental exposures (e.g., heat waves). Health impact assessments of climate change should incorporate the environmental, social and human dimensions (Ebi, et al., 2005; Parry et al., 2007). Projections of future impacts should also include a consideration of multiple exposures on specific population groups. Many of the antici-

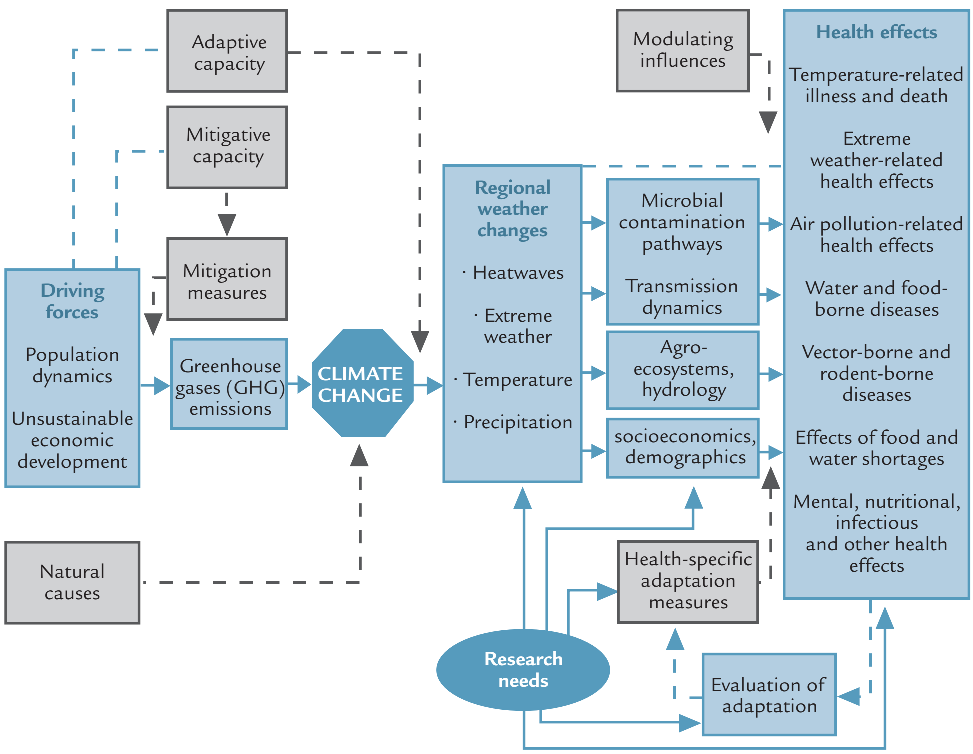
Table 10.1: Current State of Knowledge on the Impacts of Weather on Health Outcomes

Category of health outcome	Known effects of weather and climate variability
Heat stress	• Deaths from cardio-respiratory disease increase with high and low temperatures; • Heat-related illness and death due to heat waves.
Air pollution-related mortality and morbidity	• Weather affects air pollutant concentrations; • Weather affects distribution, seasonality and production of aeroallergens.
Health impacts of weather disasters	• Floods, landslides and windstorms cause direct effects (deaths and injuries) and indirect effects (infectious disease, loss of food supplies, long-term psychological morbidity).
Mosquito-borne diseases, tick-borne diseases (e.g. malaria, dengue)	• Higher temperatures reduce the development time of pathogens in vectors and increase potential transmission to humans; • Vector species require specific climatic conditions (temperature, humidity) to be sufficiently abundant to maintain transmission.
Water-/food-borne diseases	• Survival of important bacterial pathogens is related to temperature; • Extreme rainfall can affect the transport of disease organisms into the water supply. Outbreaks of water-borne disease have been associated with contamination caused by heavy rainfall and flooding, associated with inadequate sanitation; • Increases in drought conditions may affect water availability and water quality (chemical and microbiological load) due to extreme low flows.

Source: Adapted from: Kovats and Akhtar, 2008.

pated effects of climate change will not be disease-specific, but address broader determinants of health that are not readily quantified, such as poverty, displacement and access to food or water (Woodward et al., 1998). The literature is still, however, heavily biased towards quantitative assessments within prescribed scenarios for easily measured (and costed) outcomes (Watkiss and Downing, 2008).

Figure 10.1: Pathways by which Climate Change may affect Human Health



Source: McMichael et al., 2003.

This chapter provides a brief overview of the current state of knowledge on the potential impacts of climate change on human health. Areas will be identified where population factors are an important determinant of the risk posed by climate change on health in relation to food, water, extreme weather (including heat waves, floods) and vector-borne disease. Studies that have looked at migration (or population movement) in relation to climate change or human health will not be reviewed.

Food and Malnutrition

Hunger and malnutrition are widespread, and it is anticipated that climate change will exacerbate this by further reducing global food security. Presently, there are close to one billion people with insufficient calorie intake (FAO, 2008), and one third of the burden of disease in young children is attributable to malnutrition

(Black et al., 2008). Future impacts will depend on the trajectories of a number of factors, including the magnitude of climate change, the size of the population, their income levels and the environment in which they live, as well as (technological) developments in agriculture.

While climate change is likely to affect crop productivity, food security—and the relationship between food and health—is governed by many factors. The key determinants are: availability (the adequacy of food production and supply), stability (the consistency of these food supplies over time), accessibility (the accessibility of food to the population at large) and utility (the health of those consuming the food, and their ability to benefit from the energy and nutrients in the food they consume). Compromising any of these elements could lead to increased levels of malnutrition and poor health; future change in mean climate, extreme weather events and population size and distribution are likely to impact on each of them. However, modelling the elements of food security simultaneously is difficult, and, to date, no quantitative studies have taken account of all of them. Consequently, assessments of future hunger and malnutrition only capture a part of the picture, despite the use of specific and plausible climate and population scenarios.

A number of studies have modelled crop productivity (i.e., addressed 'availability') under various climate and population scenarios (see Parry et al., 2007, for an overview), and two recent papers illustrate the potential threat posed to populations with already high levels of malnutrition. Lobell et al. (2008) used statistical models for a range of crops grown in 12 food insecure regions to estimate productivity in 2030. They found that, in the near future, changes in temperature and rainfall are likely to reduce the crop yields of various food sources, particularly in South Asia and Southern Africa (Lobell et al., 2008). Battisti and Naylor (2009) looked to the end of the 21st century and suggest that, by that time, there is a 90 per cent probability that growing-season temperature will exceed even the most extreme temperatures seen during 1900 to 2006. This could severely reduce crop productivity and may place three billion people, most of whom depend on agriculture for their livelihood, at risk. The areas expected to be most affected are tropical and sub-tropical Africa and Asia and parts of South, Central and North America and the Middle East (Battisti and Naylor, 2009).

Where food is grown ('availability') may not be where it is consumed ('access'). The global trade in food is a determinant of access and relates to cost and the ability of populations to purchase food. While climate change is estimated to increase the population at 'risk of hunger' due to reduced crop productivity, socio-economic factors will have a far greater impact. In scenarios in which population growth is decreasing and there is strong economic growth, the models suggest that hunger could decrease by more than 75 per cent from current levels by 2080 (Schmidhuber and Tubiello, 2007). In addition—driven almost entirely by socio-economic factors but contingent on assumptions made within scenarios—the region with the greatest number of hungry people is expected to shift from South Asia to sub-Saharan Africa by the 2080s. Of course, despite their relative importance, development pathways will not occur independently of climate change;

increases in wealth, narrowly defined, could come at the expense of significantly increased greenhouse gas emissions which would result in greater impacts of climate change on food production.

None of the above studies include impacts of extreme weather events, such as droughts, or 'surprise' events, such as pest invasions ('stability'). Hence, the impact of climate change, which has the potential to increase both of these, could be reasonably expected to be greater than the models suggest. Furthermore, the effects of a lack of food are magnified by other factors such as diarrhoea prevalence ('utility'). If a population lacks improved water sources and sanitation which result in high rates of diarrhoea, there will be more malnutrition associated with a given level of food consumption. A multi-country analysis found that approximately a quarter of malnutrition in children aged two could be attributed to having had five or more episodes of diarrhoea (Checkley et al., 2008).

Overall, future hunger and malnutrition will be driven by a range of influences, which will, in turn, be related to both climate and population changes. Other factors, such as governance that ensures equitable access to food, will be critical.

Water and Health

Climate is a key determinant of water availability. Surface water availability depends on the timing and volume of precipitation. The current burden of disease as a result of inadequate access to improved water sources and sanitation has long been recognized, particularly the very high rates of infant mortality in deprived urban areas (Kosek et al., 2003). There are clear social and economic reasons for the lack of access to improved water at the household level. However, populations in both high- and low-income countries have experienced failures in supply due to extreme droughts. It is also known that access to water is not equally distributed within cities, and any reductions in supply are likely to have a greater impact on impoverished populations.

Climate impact assessments are often conducted at the river catchment level and converted to water availability per capita or withdrawal-to-resource ratio. Such indicators are useful to some extent, but they provide no information on the level of access to water, the quality of water or any differences between rural or urban areas. Climate change is likely to cause a decline in environmental water resource availability in certain areas, where water resource management is poor or non-existent. This will have a negative impact on water availability at the household level.

The impact of climate change on water availability is likely to be one of the most significant for the health of populations. However, due to the complexity of the factors that determine access to clean water (social, political, environmental), the impacts on health are not well addressed in the climate impacts literature. Although disease rates can be reduced very cost effectively by improvements in hygiene behaviour, such improvements require access to sufficient quantities of water. In one study, interventions to improve water quality failed to deliver a significant reduction in diarrhoeal disease in places where water availability was limited

(Esrey et al., 1991). As discussed below, heavy rainfall and flooding are also important issues for environmental health in urban areas (Kovats and Akhtar, 2008).

Emerging Infectious Disease

Many infectious diseases of animals, humans and plants will be affected by climate change (Brownlie et al., 2006a), and diseases transmitted by cold-blooded vectors will be the most susceptible to climate effects. According to the United Kingdom Foresight review, future expectations of infectious disease are based on an understanding that the majority of 'emerging and re-emerging' human infectious diseases originate in animal sources. Since these animals are likely to face continued incursions into their natural habitat, trade for meat and exotic commodities, as well as their presence as pets, the trend of one or two new human pathogens identified each year is expected to persist (Brownlie et al., 2006b). Climate-change impacts should therefore also be seen in the context of these other important drivers of the emergence of infectious disease and the large changes that are already occurring.

The global burden of vector-borne diseases, especially malaria, remains high (Thomson et al., 2006). Climate factors affect both malaria-carrying mosquito vectors and malaria parasite development rates. Although the overall impact of climate change is uncertain, it is likely to facilitate vector expansion to higher altitudes in highland areas surrounded by endemic transmission (Tanser et al., 2003). The East African highlands are densely populated and therefore potentially at an increased risk of malaria due to climate warming. Malaria epidemics are of particular concern as they occur in populations that lack partial or full immunity to the disease and thus experience high mortality rates across all age groups (Cox and Abeku, 2007).

Examples of evidence for climate effects on other infectious diseases include (IRI, 2005):

- **Meningitis:** Occurrence in the Sahelian dry season is associated with increases in temperature and decreases in humidity and is related to dust. Epidemics occur in environmentally suitable districts during the dry season and end with the first rains. There is a moderately strong relationship between climate and outbreaks of meningitis that is not well understood.

- **Cholera:** Outbreaks are associated with increases in sea surface temperatures (related to ENSO), in addition to poor sanitation and hygiene behaviour. The association between climate and cholera outbreaks is strong in the coastal regions of Bangladesh.

- **Rift Valley Fever:** Epidemics (animal and human) are related to short-term increases in rainfall. Cold weather is associated with the end of epidemics. Rift Valley Fever is moderately sensitive to climate variability.

- **Leishmaniasis:** is associated with an increase in temperature and rainfall. Outbreaks of leishmaniasis show a moderate variability based on climate.

Although vector-borne diseases are strongly affected by rainfall and temperature, which can trigger outbreaks, the longer-term impacts on these diseases due to climate change is less clear. The effects will depend on the current distribution of the disease (many diseases are well within the climate-limits) and the capacity of countries to control the infection over the next decades.

Flooding and Disasters

Flooding and tropical cyclones are the most common 'natural' disasters, accounting for 40 per cent of the 1,062 recorded disasters between 2004 and 2008. Each year, around 120 million people are exposed to tropical cyclones and storm surges, which caused an estimated 250,000 deaths between 1980 and 2000 (Nicholls et al., 2007). Single events can be devastating: In Bangladesh, tropical cyclones in 1970 and 1991 caused 300,000 and 140,000 deaths, respectively (Kron, 2005). The impact of an event, however, is greatly modified by population vulnerability. For example, similar numbers of people are exposed to tropical cyclones in Japan and the Philippines each year (22.5 million and 16 million, respectively), but the death toll in the Philippines is 17 times higher than that in Japan (UNISDR, 2009). Considering low-income countries as a group, the relative mortality risk is close to 200 times higher than in countries of the Organisation for Economic Co-operation and Development (OECD) (UNISDR, 2009). These figures highlight the influence of both climate and population factors on health impacts.

Future trajectories of the population at risk of flooding have been developed using a global coastal flood model (Nicholls, 2004). The model was run for the climate and socio-economic scenarios developed by the IPCC for the *Special Report on Emissions Scenarios* (SRES) (IPCC, 2000). When socio-economic scenarios for a world with declining population growth and robust economic development are considered without climate change, the numbers at risk of flooding increase until the 2020s and then decline significantly by the 2080s. The initial increase in numbers at risk is driven by the model's assumptions that coastal populations will grow at twice the rate of the whole population and that, while increasing wealth will lead to improved flood defences, the time it takes to build new coastal defences is approximately 30 years. In socio-economic scenarios with high population growth and lower economic growth, the numbers at risk of flooding continue to rise beyond the 2080s.

When sea level rise due to climate change is included in the model, significant additional impacts are not evident until the 2080s, when, depending on the scenario used, between 2 and 50 million additional people are estimated to be at risk. The model does not account for the possibility of an increase in the frequency and intensity of tropical cyclones and storm surges, which have the potential to greatly increase flood risk attributable to climate change. Overall, the model suggests that the population size, the areas in which they live, their wealth (in terms of ability to build flood defences) and the increased risk of flooding attributable to climate change will all be critical determinants of future flood risk.

Heat Waves

An increase in heat waves is one of the most certain impacts of climate change. All populations are affected by extremes of temperatures. Epidemiological studies have mostly been undertaken in populations in temperate climates, where mortality is shown to increase in hot and cold weather. Heat mortality risk varies by age and with other social and environmental factors (Kovats and Hajat, 2008). The majority of European studies have shown that women are more at risk of dying in a heat wave. There may be some physiological reasons for an increased risk in elderly women (Burse, 1979; Havenith, 2005), but social factors are also important. Elderly men are more at risk from heat waves than women in the United States, and this was particularly apparent in the Chicago heat wave in 1995 (Semenza et al., 1996; Whitman et al., 1997).

In addition to the 'natural' patterns of ageing (or senescence) on homeostatic mechanisms, several medical conditions increase vulnerability to heat stress (Stafoggia et al., 2006; Schwartz, 2005). Many deaths that are 'attributed' to heat do not result from heat stroke or are even in persons that exhibit the clinical signs of heat stress. It is likely that there are several mechanisms by which a person may succumb during a heat wave, as the environmental temperature places extra strain on the body. If the exposure to heat is severe enough, even healthy people will succumb to heat stroke.

Climate change is likely to increase the number of heat-related deaths in temperate populations. Less is known about heat effects in tropical or sub-tropical regions. A main uncertainty in estimating the future impact of climate change on heat-related mortality is the extent to which, even without specific adaptation strategies, physiological adaptation and factors such as behavioural changes in hot weather will reduce impacts in the general population. Physiological acclimatization to hot environments can occur over a few days, and this can explain why the impact of the first heat wave on mortality is often greater than that of subsequent heat waves during a single summer. The rate at which infrastructural changes will take place is likely to be much slower. Neither the magnitude nor the time course of the various modifying factors can be predicted with any confidence. It is clear that preventive measures will be needed to counter the substantial initial adverse effects of heat, and long-term changes are required in housing and urban infrastructure (Kovats and Koppe, 2005).

Implications for Adaptation

The implementation of adaptation strategies in relation to health is only just beginning. The WHO 61st World Health Assembly 2008, held in Geneva, 19-24 May 2008, called on Member States for more action on protecting health from the effects climate change (WHO, 2008; McMichael et al., 2008). Countries are, in fact, mandated under the United Nations Framework Convention on Climate Change (UNFCCC) to undertake national assessments of adaptation and vulnerability as part of their National Communications. Assessments of adaptation in the least-developed countries have been supported by the National Adaptation Programmes of Action (NAPA) process. Yet health is generally not well addressed in these reports. A few countries have undertaken more detailed health impact assessments outside the UNFCCC framework, for example, the United Kingdom (Department of Health and Health Protection Agency, 2008), Canada (Health Canada, 2008) and Portugal (Casimiro and Calheiros, 2002).

Estimating the potential impacts of climate change on specific health outcomes and providing information for decision makers is made difficult by the complexity of the relationships among environment, population and health. Future population trends and demographic processes will play more than a modifying role in this; they will be key factors in determining which health impacts are seen and where. The rate of growth of coastal cities in areas prone to tropical cyclones, and the level of protection put in place, could greatly influence future mortality. The diversity of livelihoods will influence the vulnerability of rural populations to malnutrition when drought causes crop failure. Infrastructure, and the distribution of access to it, is likely to affect whether the potential for greater spread of diarrhoea-causing pathogens in warmer climates leads to increased child mortality. In addition, population health itself is not only an outcome, it is also a vulnerability: A chronically malnourished population will be particularly susceptible to acute food shortages due to extreme weather events.

Protecting and improving human population health requires new research on climate-health links, as well as improved methods to guide adaptation strategies. To identify future health threats and the populations likely to be affected by them, epidemiological methods and modelling strategies—which have conventionally focused on less complex risk-outcome structures—need to be further developed and, in particular, applied in low-income settings. In order for such research to be used to develop policy, it should, where possible, specifically consider the influence of socio-economic and demographic factors. It is often possible to include these when assessing the past and present. However, when considering future impacts, the application of such findings is difficult, as quantitative descriptions of plausible future socio-economic and demographic conditions are generally limited to GDP and to population in terms of numbers and age-stratification.

Means to overcome these limitations include the development of scenarios with more detailed quantitative descriptions of plausible future worlds and the modification of methods for assessing the means of adaptation in the face of particular health threats. Additionally, methods of assessing and characterizing uncertainties in health assessments need to be further developed and should focus particularly on ensuring that the characterization is useful to policymakers. Given that many adaptation strategies have long lead times, it is critical to ensure that the uncertainties inherent in the still developing field of climate-health research do not prevent appropriate actions from being taken.

Climate change is a unique health threat in that it will affect all populations and requires consideration of extended time frames. In the near term, many of the mechanisms by which health will be affected are known—although the magnitude of the impacts and effectiveness of prevention are highly uncertain. There are likely to be many changes that are unanticipated involving ecological shifts or emerging infections. Under the higher projections of warming (more than 2-3°C above pre-industrial climate), the uncertainty is greatly increased (Kovats et al., 2005). This rate of change is unprecedented for humans and has unknown implications.

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11

Population and Reproductive Health in National Adaptation Programmes of Action (NAPAs) for Climate Change

Clive Mutunga
Karen Hardee

Introduction

Perhaps the greatest irony of climate change is that countries that have had the least to do with growing emissions are likely to experience the most severe impacts. Due to the persistence of carbon in the atmosphere, global warming is inevitable in the coming decades under any scenario produced by the Intergovernmental Panel on Climate Change (IPCC), and global greenhouse gas emissions will continue to increase at least up to the year 2020 (IPCC, 2007). While mitigation is critical, there is a growing consensus that helping affected countries and people adapt to climate change is also important since the impacts of climate change are already being felt and will worsen in the future (IPCC, 2001; Huq et al., 2003; AIACC, 2004; UNFCCC, 2007a; UNDP, 2008; FAO, 2008; UNFCCC, 2009).

While most of the international focus is on mitigation of climate change, including through well-publicized international conferences and agreements such as the Kyoto Protocol, adaptation as a response to the climate change problem has gained importance in the international policy agenda (Reid and Huq, 2007). For example, the Bali Action Plan, an addendum to the United Nations Framework Convention on Climate Change (UNFCCC), recently identified the need for enhanced action on adaptation (UNFCCC, 2007a).

A large share of the population in developing countries is already vulnerable and living in marginalized areas that are susceptible to climate variation and extreme weather events. Population growth is occurring most rapidly in the developing world, increasing the scale of vulnerability to the projected impacts of climate change. In 2005, the average population density in developing countries was 66 people/km^2 compared to 27 people/km^2 in developed regions (Jiang and Hardee, 2009). More than half (27) of the 49 Least Developed Countries (LDCs) are projected to at least double their current population by 2050, based on the most recent population projections of the United Nations. Human population growth will increase vulnerability to many of the most serious impacts of climate change. Scarcity of food and water, vulnerability to natural disasters and infectious diseases and population displacement are all exacerbated by rapid population growth (Jiang and Hardee, 2009; GLCA, 2009).

Recognizing that LDCs, including developing Small Island States, are among the most vulnerable to, and have the least capacity to cope with, extreme weather events and the adverse effects of climate change, National Adaptation Programmes of Action (NAPAs) were established as part of the Marrakech Accords of the 2001 UNFCCC Conference of Parties (COP). NAPAs were intended to provide assistance to LDCs in developing plans to address the adverse effects. NAPAs, which are supposed to link with national development processes, provide an avenue for LDCs to identify priority activities that respond to their urgent and immediate adaptation needs.

What is the experience with NAPAs to date? What interventions are being included in NAPAs? Are population and reproductive health/family planning (RH/FP) addressed in NAPAs, including through projects proposed by countries? This chapter begins with a description of the NAPA process and a discussion of their development, preparation and financing. It then analyses how population factors are addressed in NAPAs and the range of adaptation interventions identified and prioritized by countries, including RH/FP. The chapter ends with a discussion of the challenge of addressing population and RH/FP through the existing NAPA process and a discussion of how NAPAs are aligned with national development processes. Finally, the chapter makes suggestions for the NAPA process to include more integrated programming that links with development strategies.

Methodology

The 41 NAPAs that were submitted as of May 2009 were included in the analysis. Relevant information on all NAPAs and projects was assembled by the authors into an Excel database. Analysis focused on this database and on content of the NAPAs and projects. This information was supplemented by a review of the literature on NAPAs, adaptation and the relationship between population and climate change.

Development, Preparation and Financing of NAPAs

Among the 49 eligible LDCs, 41 (85 per cent) have submitted their NAPAs to UNFCCC. In addition, three NAPAs are in the final stages of preparation and are expected to be completed by the second quarter of 2009. Finally, preparation has been initiated in four countries, and the NAPAs are expected to be completed before the end of 2009. The current status of preparation of the NAPAs is presented in Table 11.1.

According to UNFCCC, the rationale for developing NAPAs rests on the high vulnerability and low adaptive capacity of LDCs, many of which count among some of the world's poorest. This demands, in turn, the immediate and urgent support for projects that allow for the adaptation to the adverse effects of climate change. As such, "activities and projects proposed through NAPAs are those whose further delay could increase vulnerability or lead to increased costs at a later stage" (UNFCCC/LEG, 2002, p. 1). Acknowledging that countries need to have

Table 11.1: Analysis of NAPAs

	Number
Development and Preparation of NAPAs	
Total NAPAs submitted [as of May 2009]	41
NAPAs available in Draft form	1
NAPAs in preparation stage	6
Total number of priority projects identified in NAPAs	448
NAPAs not clearly demonstrating linkages to national development planning processes including Poverty Reduction Strategies (PRSs)	31
NAPAs' Coverage of Population and Reproductive Health/Family Planning (RH/FP) Issues	
NAPAs recognizing 'rapid population growth' and linking it to climate change	37
NAPA mentions RH/FP and links it to adaptation strategy	6
NAPA identifies RH/FP project as part of country's priority adaptation strategy	2
Total number of RH/FP projects that have been funded	0
Number of LDCs whose population is projected to at least double by 2050	27
Unmet Need for Family Planning among LDCs	**Per Cent**
Countries with over 20 per cent unmet need for family planning	80
Countries with over 10 per cent unmet need for family planning	90

national adaptation plans which identify and prioritize not only urgent and immediate needs but also medium- and long-term needs, longer-term national adaptation plans are part of the on-going UNFCCC negotiations.[1] It was envisaged that NAPAs would fit into the longer-term national plans of adaptation.

Following NAPA guidelines, countries undertake four steps to develop their NAPAs: 1) establish a NAPA organization that should include local communities and representatives from various sectors (e.g., agriculture, water, energy, forestry, health and tourism); 2) synthesize available information on impacts, coping strategies, national and sectoral development plans to provide a baseline measure of vulnerabilities; 3) identify projects through consultations with stakeholders and develop a list of priority projects; and 4) submit the NAPA to UNFCCC.

An important guiding principle in the preparation of NAPAs is that the process ought to be a bottom-up, participatory approach that involves a broad range of stakeholder groups and focuses on local communities, considering their current vulnerability and urgent adaptation needs (UNFCCC/LEG, 2002).

Financing is a key component of NAPAs. Although estimates of the funding required to assist developing countries to adapt to the impacts of climate change vary widely,[2] there is general agreement that the cost could be in the range of tens of billions of dollars per year. The total indicative estimated cost of implementing the 448 projects prioritized by the 41 NAPAs is over US$800 million,[3] yet, currently, the NAPAs fund, the Least Developed Country Fund (LDCF), has mobilized about US$176 million, hence showing a huge disparity between the financial needs of NAPAs and the mobilized financial resources. Furthermore, there is consensus that resource shortfalls hinder funding of NAPAs and that countries are generally underestimating the costs of adaptation (Agrawala and Fankhauser, 2008; CCCD, 2009).

How NAPAs Characterize Population as a Factor Related to Climate Change

Analysis of NAPAs to explore how they describe population dynamics and climate change showed that most NAPAs identify population and health issues as relevant for climate change adaptation strategies.

Thirty-seven NAPAs explicitly make linkages between climate change and population and identify rapid population growth as a problem that either aggravates the vulnerability or reduces the resilience of populations to deal with the effects climate change (Table 11.1). Although the different NAPAs have diverse concerns, the effects of rapid population growth have been linked with climate change through five factors: food insecurity; natural resource depletion/degradation; water resource scarcity; poor human health; and migration and urbanization.[4]

Population pressure and food insecurity

Thirty-five NAPAs link high population growth to food insecurity. Population pressure contributes to this by increasing a country's vulnerability to food shortages in the event of occurrences such as droughts and floods and by increasing demand for food and putting additional pressure on the food supply system and already diminishing food resources, for example, fish stocks, as reported in Bangladesh, Gambia, Kiribati, Solomon Islands and Tuvalu.

Population pressure is more pronounced in certain areas that are more susceptible to events such as droughts and floods. For instance, NAPAs recognize high populations residing in low-lying coastal areas (Samoa, Solomon Islands), hilly or mountainous areas (Tuvalu) and on scarce arable land (Central Sudan along the Nile River, Uganda).

Population pressure and natural resource depletion/degradation

Natural resource depletion or degradation is a central theme of the NAPAs and is often linked to population pressure. Excerpts from selected NAPAs indicate that rapid population growth: "*results* in the imbalance of the already limited resources and the threat of climate instability" (Comoros), "*is a cause* of decline in resources base" (Ethiopia), "is *partly contributing* to unsustainable natural resource use" (Gambia), is "*linked to* environmental resource stress" and "*leads to* excessive fishing and to structural changes to the shoreline" (Kiribati), has "*led to* ecological imbalances expressed by the deterioration of livelihoods" (Niger), is "an important factor of pressure on the environment" (Haiti), is "*placing pressure* on sensitive environments"(Tuvalu) and "*tend[s] to* degrade highland ecosystem" (Uganda) [emphasis added].

Population pressure is directly linked to deforestation in the NAPAs of Mozambique, Rwanda, Sierra Leone, Solomon Islands and Uganda. The Uganda NAPA goes further in associating high population density with observed biodiversity loss.

Population pressure and water resource scarcity

Population pressure is deemed to increase the demand for water and further reduce its future availability. In Sudan, for example, "unfavorable weather conditions combined with population growth has rendered the Setaite River incapable of sustaining the town of Gedarif". Water scarcity is identified as a common problem in Tuvalu and is associated with the growth in population and urbanization. Vanuatu's NAPA acknowledges that population growth, particularly in urban areas, has already placed pressure on water resources and supply services and that climate change is likely to increase demand for water while impacting on both the quantity and quality of water resources. Population increases in urban centres have put pressure on groundwater, as noted by Zambia's NAPA.

Population pressure and poor human health

A number of NAPAs link population and climate change to risks to human health. Kiribati notes that the spread of waterborne diseases is associated with high population density in urban areas. Maldives' NAPA asserts that "the vulnerability to climate change related health risks is further compounded by local characteristics such as the high level of malnutrition in children, accessibility and quality of healthcare, high population congestion and low income levels". In Tuvalu, the NAPA contends that "overpopulation" increases pressure on resources and risks of waterborne diseases. In Uganda, the NAPA notes, heavy rainfall has led to flash floods and resulted in the outbreak of waterborne diseases such as diarrhoea and cholera, while prolonged dry spells have resulted in outbreaks of respiratory diseases. Population pressure increases the country's vulnerability to these diseases and its ability to cope with increased health costs.

Population pressure, migration and urbanization

Eighteen NAPAs link climate change to another major demographic concern, migration. Climate change imposes additional burdens on communities already facing migratory challenges caused in part by rapid population growth. The migrating populations, either in search of new agricultural lands and pastures or urban areas, are already economically vulnerable, and this vulnerability is increased since, in most cases, the zone that receives them is often already faced with a high risk of economic, social and environmental vulnerability.

The migration of people and cattle, noted as one of the traditional adaptation strategies in Burundi and Niger, is identified as one of the real and potential adverse impacts of climate change. The migration of at least 10 per cent of the population and a loss of cultivable lands is an anticipated impact of climate change in the Comoros, while, in the United Republic of Tanzania, people living along the coast will be forced to migrate, something which may cause social conflicts and environmental degradation due to rapid population growth.

In Burkina Faso and Rwanda, people migrating from densely populated regions looking for better living conditions in less-populated areas not only increase their vulnerability by exposing themselves to a high risk of drought and desertification in the recipient areas but also by contributing to further degradation.

Climate change will have a significant impact on urban settlements, especially in the face of increasing population and continual urban migration. Samoa's NAPA notes that poor drainage systems, lack of strategic planning and an increasing urban population will only exacerbate the impacts of climate change on urban settlements. In Djibouti, the NAPA notes, unfavourable climatic conditions have led to migration from rural areas to "new urban areas" where previously nomadic populations are being forced to settle around water points established by the State. Rapid urbanization in Gambia is "paralleled by clearing of forests and woodlands, expansion of cultivated area, over-fishing of particular species and severe coastal erosion".

The Solomon Islands' NAPA asserts that, with an increasing population, waste management problems are an issue of increasing concern. In Sao Tome and Principe, the relocation of the population at risk of food insecurity and landslides in Malanza, Santa Catarina and Sundy was identified as a priority adaptation activity.

In summary, NAPAs are quite thorough in their treatment of the effects of population and climate change, although analyses of demographic factors, including age structure and household size, are not adequately addressed. A number of researchers have identified analysis of these demographic factors as important for understanding the links between population and climate change (Jiang, 1999; Jiang and O'Neill, 2004; Liu et al., 2003; Mackellar et al., 1995; Prskawetz et al., 2004; van Diepen, 2000).

Given that population is highlighted in most NAPAs, it follows that projects to address the effects of rapid population growth are included among priority projects. The next section examines which sectors and projects were prioritized in the NAPAs.

Sectoral Classification of Submitted NAPA Projects and Priority Projects

The total number of priority adaptation projects identified in the 41 NAPAs is 448, although the number of such projects varies widely among the countries. Using the same classification as UNFCCC (2009), identified projects fall into 12 broad categories, as shown in Figure 11.1. Some projects and activities are difficult to classify into any one sector, therefore UNFCCC includes them in a cross-sectoral category. In the NAPA preparation process, projects are ranked by the stakeholders in order of importance, subject to select criteria, including the expected outcomes of the projects, for example, mitigating adverse effects of climate change, poverty reduction to enhance adaptive capacity, synergy with multilateral environmental agreements and cost effectiveness (UNFCCC/LEG, 2002).

Figure 11.1 shows the distribution of projects by sector. Half of the projects fall into three sectors: food security, terrestrial ecosystems and water resources. This can be explained by the fact that agriculture, livestock, fisheries and other income-generating activities rely on terrestrial ecosystems and water resources which are important for feeding and sustaining livelihoods for millions of people. The health sector accounts for around 7 per cent of the total projects, after food security (21 per cent), water resources and management (16 per cent), terrestrial ecosystems (15 per cent), cross sectoral (9 per cent) and coastal zones and marine ecosystems (8 per cent). In addition, in the Solomon Islands and Sudan, two cross-sectoral projects have health sector components. The fewest identified priority projects are in the tourism, insurance and energy sectors.

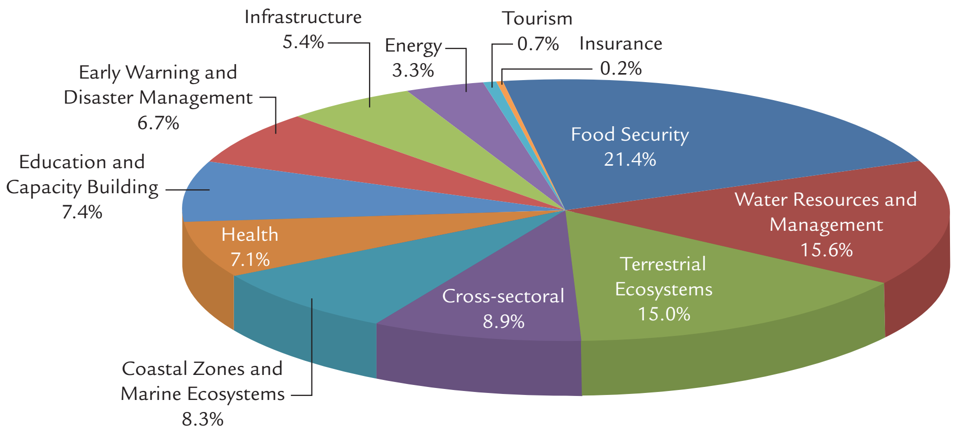
All 41 countries identify the health sector as among the most vulnerable to climate change. However, less than half of the countries (18) have proposed a single project in this sector. In terms of priority project ranking, projects in the health sector are generally not ranked among the first five priorities in any of the NAPAs (Figure 11.2). Indeed, the ranking of the priority projects follows the same pattern as the distribution of the projects by sector. Health sector projects would therefore be ranked 6th in terms of priority.

In an analysis of 14 NAPAs by Osman-Elasha and Downing (2007), a major weakness identified during the preparation of NAPAs was the institutional barriers that hindered a free exchange of information, including communication problems between central offices and regions or provinces. The authors found that NAPA coordination teams are mainly found either under the umbrella of environment or the meteorology departments and also mostly host/house UNFCCC Focal Points. This composition of the teams has implications for the content of the NAPAs and may explain the low priority given to health—and by extension, RH/FP.

Reproductive Health/Family Planning and Adaptation Strategies in NAPAs

Since most of the NAPAs identify rapid population growth as an integral challenge to adapting to climate change, it follows that slowing population growth should be a key component in dealing with the effects of climate change. Reduced population pressure can ameliorate some of the effects of climate change and/or increase the ability of countries to adapt. RH/FP has been recognized as one of many strategies that can slow population growth and reduce demographic pressure (Ross, 2004; Moreland and Talbird, 2006). Yet, as mentioned above, there is limited identification of adaptation projects in the health sector, under which RH/FP broadly falls. In addition, the

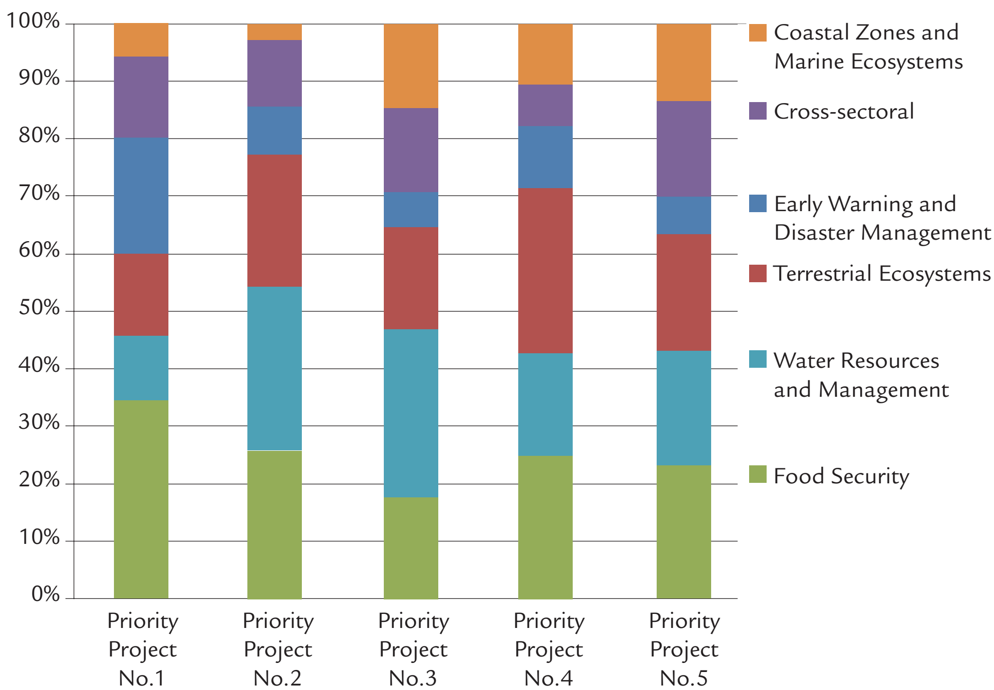
Figure 11.1: Distribution of NAPA Projects by Sector



identified health-sector projects are not ranked highly among the priority actions, and priority actions are more likely to be implemented.

Only six NAPAs, described below, clearly state that slowing of population growth or investments in RH/FP should be considered among the country's priority adaptation actions (Table 11.1). These countries include the Comoros, Ethiopia, Gambia, Kiribati, Uganda and Zambia. Furthermore, among those NAPAs that clearly make this case, only Uganda actually proposes a project with components of RH/FP among its priority adaptation interventions. Another project with RH/FP components is proposed by Sao Tome and Principe, but its NAPA

Figure 11.2: Priority Ranking of NAPA Projects by Sector



neither links population pressure to climate change nor to RH/FP. In both Sao Tome and Principe's and Uganda's NAPAs, RH/FP is integrated with other priority adaptation interventions.

Comoros' NAPA notes that population growth is a source of vulnerability and credits family planning programmes for the reduction in the population growth rate. Even though the NAPA establishes clearly the linkage between climate change and FP policies, the NAPA team fails to identify a priority project with RH/FP programmes.

In **Ethiopia**, high population growth is identified as one of the causes of vulnerability to climate change. During the NAPA process, mainstreaming family planning into agriculture was proposed in the regional consultative workshops as an adaptation strategy. Although the NAPA identifies mainstreaming of family planning into agriculture as one of the potential cross-sectoral adaptation options, there is no component of RH/FP in any of the proposed priority agricultural projects.

In **Gambia**, partly as a result of population pressure, the natural environment has taken the full brunt of unsustainable use of natural resources, as seen in the negative effects on the forest cover, rangelands and aquatic and marine organisms, as the NAPA reports. Taking cognizance of this fact, the NAPA proposes the stabilization of rural populations as a strategy for adaptation. However, none of the identified priority adaptation actions have RH/FP components or other interventions designed to stabilize rural populations.

Kiribati's NAPA mentions that the country has population policies to encourage family planning, although these policies are yet to have a substantive effect. In the final ranking of projects, the NAPA team clearly identified family planning as an adaptation strategy. Surprisingly, the identified priority projects did not have a single RH/FP project among them, despite the explicit mention. However, the document distinguishes between short-term adaptation, focusing on urgent and immediate needs (through the NAPA), and long-term strategic planning for adaptation which is addressed by an existing project outside the NAPA, the Kiribati Adaptation Project, which has "support for population and resettlement" as one of its programmes.

Sao Tome and Principe's NAPA mentions the vulnerability of its essentially young (79 per cent under 35) and predominantly urban population, manifested through frequent migration by coastal populations due to an increase in floods and coastal erosion. However, the NAPA neither acknowledges population pressure nor links it to climate change or to RH/FP. Yet it is one of the few countries to identify a project with components of RH/FP. The project, ranked 3rd and titled "Communication Action for Behavior Change", has the objective of informing and sensitizing the population to behaviour changes for the prevention of diseases related to water, vector transmission and other health problems linked to climate change. It specifically includes a component on family planning counselling.

The **Uganda** NAPA makes a clear link between population and climate change and notes the need for family planning. The document identifies a negative social coping strategy, "famine marriage", where, in times of food crisis, some parents distressfully marry off their daughters to secure dowry for survival. This practice fuels early marriage, dropping out of school and exposure to sexually transmitted infections and related reproductive health complications. The NAPA team identifies the "Community Water and Sanitation Project", which includes slowing population growth through family planning, as part of a scaled-up poverty alleviation programme. However, the project profile does not mention the specific interventions in RH/FP, perhaps anticipating that NAPA project activities would link with RH/FP services in the country.

Zambia's NAPA reiterates the importance of meeting the goals of the Fifth National Development Plan (FNDP) 2006-2010, which includes integrated reproductive health with the objective of reducing the maternal mortality ratio. Despite this clear appreciation of the role of RH/FP in the NAPA and the linkage to the national development plan, the project team does not propose a project specific to RH/FP.

In summary, as shown in Table 11.1, although population is mentioned as an important factor related to climate change in 37 NAPAs, only six explicitly state that slowing population growth or meeting an unmet demand for RH/FP should be a key priority for their adaptation strategies, and only two NAPAs propose projects that include RH/FP. Neither of these projects has been funded.

Alignment of NAPAs with the National Development Planning Process

Since many of the adaptation needs identified in NAPAs are directly related to development issues, the effectiveness of NAPAs could be enhanced by integrating them into current development plans, policies and programmes, including Poverty Reduction Strategies (PRSs). Ensuring that adaptation strategies align with national development processes could link development and climate change agendas. This is important since national development plans and strategies provide a framework for domestic policies and programmes, as well as for foreign assistance, with the overall aim of reducing poverty (Bojo et al., 2004). Theoretically, NAPAs and PRSs should embrace common projects that are built upon both short-term adaptation interventions and longer-term development strategies (McGray et al., 2007).

A brief analysis of NAPAs reveals that even though all the documents have a section on the linkage of the NAPA with national development plans, the two are, in many cases, not well aligned. Two categories have been identified under which the NAPAs fall in relation to alignment with national development planning processes. The first group, consisting of about 31 countries (76 per cent), has NAPA documents which do not clearly demonstrate how they are linked to the national development processes. These documents only mention that the NAPA "was created on the basis of . . .", "has established strong linkages with . . .", or "supports . . ." the national development goals and strategies as espoused in the country's development plans without articulating any clear linkages.

The second category consists of 10 countries (24 per cent) whose documents clearly establish the linkages between the NAPA and national development plans, complete with detailed analyses of the identified vulnerabilities and proposed projects. Some of these contain matrices of analyses showing how the NAPA fits into specific national development and sectoral development goals and even into specific programmes and projects (Table 11.1).

Consensus is emerging about the disconnect between NAPAs and PRSs. A recent study commissioned by the Global Environment Facility (GEF) shows that mainstreaming adaptation into development agendas has not yet penetrated the world of PRSs (Hedger et al., 2008). According to the report, UNFCCC workshops have noted that crucially little work has been undertaken to integrate adaptation into development plans or existing poverty alleviation agendas.

A review of 19 PRSs in the 2007/2008 *Human Development Report* (UNDP, 2007) found that, although most of them cited climate events and weather variability as important drivers of poverty and constraints on human development, only four countries identified specific links between climate change and vulnerability. A similar observation was made by UNDP's Water Governance Facility (WGF) (2009), which notes that a major weakness of NAPAs is the lack of clear linkages between their content and that of PRSs and other national development strategies.

This disconnect may be due, in part, to the structural differences between development plans and NAPAs, both of which ought to be undertaken in a participatory process, with a multidisciplinary approach and a sustainable development perspective. Although the sustainable development approach implies a longer-term perspective, the guidelines for NAPAs to be "action-oriented" and "set clear priorities for urgent and immediate adaptation activities" (UNFCCC/LEG, 2002, p. 2) imply a shorter-term perspective. It is important, however, that NAPAs not only take into account short-term projects but also recognize the need for a coherent long-term adaptation strategy to which the implementation of the identified projects will contribute (WGF, 2007).

NAPAs are, by definition, project-oriented. UNDP finds that most NAPAs focus entirely on small-scale project-based interventions to be financed or co-financed by donors; this has resulted in "an upshot of a project-based response that fails to integrate adaptation planning into the development of wider policies for overcoming vulnerability and marginalization" (UNDP, 2007, p. 188). WGF (2009) corroborates this view by asserting that NAPAs generally focus on projects and are often not successful at integrating long-term development objectives. McGray et al. (2007) state that the disconnect between NAPAs and the PRSs arises from the fact that the latter are prepared by ministries of finance or planning, which are often entirely disconnected from the environment ministries most closely associated with the NAPA process. Osman-Elasha and Downing (2007) suggest viewing NAPAs as primarily important for raising awareness, at least among national stakeholders, and placing climate change adaptation on the development agenda.

The Need for an Integrated Approach to Adaptation Strategies

Although a majority of the NAPAs identify rapid population growth as an integral key component of vulnerability to climate-change impacts, few choose to prioritize NAPA funds for RH/FP programmes. Faced with multiple competing development priorities and climate-change challenges, countries prioritize projects that are geared towards the alleviation of food insecurity and water resource scarcity, which are two key problems facing LDCs. Yet, in the LDCs, unmet need for family planning, or the percentage of women who want to stop having children or who wish to wait at least two years before having another child, is high. Yemen has the highest rate (50.9 per cent), and 80 per cent of the countries have over 20 per cent unmet need (Table 11.1). Mainstreaming RH/FP into projects designed to address food insecurity and water scarcity can help slow population growth and alleviate pressure on limited food and water resources.

There is also a likelihood that a majority of stakeholders involved in the preparation of NAPAs, although recognizing the importance of stabilizing population growth to better adapt to future climate changes, do not perceive RH/FP programmes to be urgent and immediate projects but rather long-term strategic planning interventions, perhaps best addressed in national development plans and PRSs. It is important to note, however, that population and RH/FP issues have not been adequately addressed by PRSs either. According to a World Bank review (2007), most of the PRSs recognized population growth as an important issue for poverty reduction and included objectives and strategies but failed to translate these into specific policies or indicators to measure progress over time. An unpublished review of 45 PRSs found that while two thirds of them mention family planning, less than half include any implementation details (Borda, 2005).

This view is given credence by the Kiribati NAPA, which clearly distinguishes between short-term adaptation for urgent and immediate needs (through the NAPA) and long-term strategic planning for adaptation (addressed by an existing project outside the NAPA, the Kiribati Adaptation Project, which has support for population and resettlement as one of its programmes). Even though the NAPA guidelines state the importance of aligning projects to long-term sustainable development planning, they place greater focus on urgent action, which may be construed by NAPA stakeholders to imply short-term rather than long-term planning and development.

Components of health and RH/FP, however, could be integrated into projects in other sectors, as has been done in the NAPAs from Sao Tome and Principe and Uganda. For example, integrating health into projects that focus on agriculture and water resources, which have a higher likelihood of being given a high priority for NAPA funding, would improve the chances of RH/FP being implemented. Furthermore, such integrated projects are more likely to meet the needs of vulnerable populations, which face risks in all aspects of their lives—food, shelter, livelihoods, health, etc., including their voiced desire to stop or space childbearing.

Conclusions and Recommendations

NAPAs are a major mechanism through which adaptation funding is to be provided to LDCs, which are likely to face the most severe impacts of climate change. This chapter has shown that the NAPA process favours short-term project responses to climate change adaptation and that priority tends to be given to single-sector projects focusing on food security and water resources. The NAPA process has also not been successful in aligning urgent and immediate actions to address vulnerability to climate change with existing national development planning processes, including PRSs, despite the requirement to do so. Thus, LDCs—and the global community—are missing an important opportunity to link meeting immediate and short-term adaptation needs with longer-term development issues, including the Millennium Development Goals (MDGs), that will also strengthen people's ability to adapt to climate change.

Furthermore, demand for funding exceeds current available resources for NAPAs, indicating that developed countries are not meeting their promises to fund adaptation to climate change in the most affected countries.

Since environmental degradation and climate change have been linked to demographic factors, including population growth, slowing the rate of growth should be among the strategies implemented through NAPAs—and through national development plans. Voluntary RH/FP that respects the rights of individuals to choose the number and spacing of their children is recognized as one of many strategies that can help improve livelihoods and protect the environment by slowing population growth and reducing population pressure. RH/FP, included with investment in girls' education, economic opportunities and the empowerment of women and investments in youth, which are all part of the MDGs, can help developing countries speed up their demographic transition from high to low fertility, lower mortality rates and will likely help people adapt to climate change.

This analysis of NAPAs shows that population pressure is recognized as an issue related to the ability of countries to cope with climate change. Thirty-seven of the 41 NAPAs submitted broadly recognize and link rapid population growth to challenges the countries face in adapting to climate change. However, these linkages are not matched by a proportional response through adaptation projects that address population, including access to voluntary RH/FP. Only two countries among the 41 include RH/FP projects in their NAPAs, and neither of those projects has received funding.

This review leads to five recommendations:

- The favouring of single-sector projects within the NAPAs over integrated programmes does not reflect people's lives. Strategies for adaptation should reflect a multisectoral approach that recognizes that people do not live in single sectors. People deal simultaneously with food, water, livelihoods, health and education, among other issues, including reproductive health. Wherever appropriate, projects or programmes funded through NAPAs should be integrated across sectors to avoid 'winner' and 'loser' sectors.

- The focus of NAPAs on short-term projects, rather than on linkages with development strategies that address medium- and longer-term issues, is inadequate. As countries develop longer-term adaptation strategies, a mix of short- and longer-term projects that involve participation across development sectors is important to ensuring a wide range of adequate responses in adapting to climate change that can save lives and, ultimately, strengthen livelihoods.

- NAPAs should translate the recognition of population pressure as a factor related to the ability of countries to adapt to climate change into relevant project activities. Such projects should include access to RH/FP, in addition to other strategies that reduce unwanted fertility, such as girls' education, women's empowerment and a focus on youth.
- Countries that have already clearly identified RH/FP projects in their NAPAs should expedite their implementation.
- Attention to population and integrated strategies should be central and aligned to longer-term national adaptation plans and strategies currently being discussed as part of enhanced action for adaptation.

Notes

1 Longer-term national adaptation plans are part of the UNFCCC discussions on enhanced action on adaptation taking place under the "Ad Hoc Working Group on Long-Term Cooperative Action" (AWG-LCA) and were featured at its 6th Session held in Bonn, 1-12 June 2009.

2 The estimated annual costs of adaptation (US$) range from 31 billion (Stern, 2006), 34 billion (The World Bank, 2006), 55-135 billion by 2030 (UNFCCC, 2007b), 50 billion (Oxfam International, 2007) to 89 billion by 2015 (UNDP, 2007).

3 The total cost of implementation of all the NAPAs is currently estimated at US$2 billion by Oxfam and the International Institute for Economic Development (IIED), revised up from the original US$1.6 billion. This was based on an extrapolation of the costs of submitted NAPAs.

4 This classification was guided by an unpublished analysis on population and NAPAs by MSI and PSN (2009) characterizing population as affecting climate change primarily in three ways: "(1) by acting in tandem with climate change to deplete key natural resources, for example through soil erosion and deforestation, (2) by causing a significant escalation in demand for resources, such as fresh water and food, that are declining in availability due to climate change, and (3) a heightening of human vulnerability to the effects of climate change, including by increased pressure on human health and by forcing more people to migrate and settle in areas at risk of extreme weather events" (p. 7).

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12

The Use of Population Census Data for Environmental and Climate Change Analysis

José Miguel Guzmán[1]

Introduction

Despite their potential uses for environmental studies and climate change analysis, censuses have not been sufficiently exploited as key data sources. This neglect was particularly obvious at recent specialized conferences (such as the Conference on Climate-Change and Official Statistics held in Oslo, Norway, in April 2008 and the International Conference on Climate Change, Development and Official Statistics in the Asia-Pacific Region, held in Seoul, Korea, in December 2008), where population censuses were rarely mentioned.[2] In one of the most important frameworks for climate-change adaptation in least-developed countries, the National Adaptation Programmes of Action (NAPAs), census data are rarely used. When they are used, it is primarily to report the most basic population statistics without further analysis of impacts across categories of sex, age or specific vulnerabilities.

However, the information required to investigate and analyse the linkages between environmental changes and the socio-economic and demographic conditions of the population have increased significantly in recent years; the increased availability of census data at a smaller scale can thus make a significant contribution. Censuses collect information on all households, which allows for the production of statistics for small areas that can then be analysed for specific objectives using tailored methodologies. The limit for the level of detail depends on the protection of the confidentiality of census data.

The 2010 Census round could become one of the most important sources of data for environmental analysis[3] and, in particular, will provide additional information that can aid in the calculation of emissions and in the identification of those populations vulnerable to the environmental disasters caused by climate change, thus providing an evidence base for both mitigation and adaptation policies. Three main challenges need to be addressed: 1) what needs to be done to ensure that relevant questions are included in the censuses and that those that are usually included are adequate to meet current needs; 2) what needs to be done to ensure that census data are collected and processed to facilitate detailed analysis of very small areas (preferably environmentally homogeneous areas); and 3) what needs to be done to ensure that census data are made available, disseminated, analysed and used for national mitigation and adaptation policies.

This chapter will present an overview of the potential uses of census data, provide examples of the use of census data in particular countries and highlight the potential of such data to provide evidence in still unexplored areas. It aims to call attention to the need to act now in order to better position environmental statistics in censuses, through the inclusion of questions and the development of methods for processing and analysing geo-referencing population data.

The 2010 Round of Censuses

Most of the countries of the world expect to conduct their censuses around 2010. In addition to providing data on the characteristics of households and dwellings, population and housing censuses will provide information on the size, composition and characteristics of the population, as well as on many other areas, such as the spatial distribution of population, occupation, education, sex, household composition and environment, among others. The 2010 Census round will also be the main source for updates of current population estimates and projections.

The potential of population and housing censuses is indisputable. However, their use will largely be affected by the availability of the data, the degree of their dissemination, the extent of the analysis based on the information collected, the quality of the data and, most important, the relevance that is given to the census data as key inputs for policy design.

In the particular case of environmental analysis, in addition to the areas mentioned above, use of the data will depend on the availability of geo-referenced maps as well as on having census enumeration areas that are small enough to allow for linking population data to environmental-geographic data. It will also depend on the types of questions included and the categories of responses related to environmental issues. For example, to date, gender analysis of climate change issues has been notably lacking.

Limitations exist, inter alia, because censuses are conducted, in the best case, every ten years, so the data become outdated the longer the time from the date of the most recent census. In addition, the potential use of information derived from the inclusion of specific questions related to the environment can be limited due to the characteristics of the census questionnaire which only allow for the inclusion of a selected number of questions and easily identifiable categories.

The following section provides an analysis of some common questions that are included in censuses and that can be used for environment and climate-change studies (see Tables 12.1 and 12.2).

The Use of Census Data based on the Specific Questions Included

Most of the information obtained in a census can be useful for climate-change analysis. Data on the characteristics of the population (sex, age, household composition, etc.) can be used to determine the pattern and level of emissions (see Dalton et al., 2008) and the conditions and assets of a population that can be beneficial for adaptation to climate change. However, there are specific questions that can be included in the household questionnaire which can provide specific details about the anthropogenic impact on climate change. The most commonly used are listed below, mainly because they are considered to be the basic questions in the Principles and Recommendations of the United Nations for Population and Housing Censuses (United Nations, 2008). In some cases, other questions are included based on the specific needs of a country. In the case of Latin America, for example, there has been an increase in the number of countries including these questions (see Table 12.1).

Table 12.1: Number of Countries that included Selected Questions Related to Environment in Latin America, Census Rounds 1980, 1990 and 2000

Question	Number of countries by census round		
	1980	**1990**	**2000**
Energy used for cooking	10	10	13
Access to electricity	11	11	13
Waste Disposal	1	6	10

Source: CELADE.

Questions included:

1. Source of energy for cooking and lighting

Target 9 (Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources) of Goal 7 of the Millennium Development Goals (MDGs) (Ensure environmental sustainability) has, as one of its indicators, the proportion of the population using solid fuels. This indicator is important because it provides a link between household solid fuel use, indoor air pollution, deforestation, soil erosion and greenhouse gas emissions (United Nations, 2008). Therefore, this information is very relevant from the point of view of the mitigation of climate change.

Access to electricity is also a relevant indicator for environmental analysis. The need to increase accessibility to and affordability of energy services for the poorest populations in developing countries is considered essential in strategies to alleviate poverty and to contribute to social and economic development (IAEA, 2005).

The environmental impact of sources of energy for cooking and lighting are best demonstrated when combined with information on other factors such as densities, occupational distribution, land-use and tenure patterns and the level of urbanization. The level of pressure on resources can then best be brought into focus.

Table 12.2: Selected indicators of Sustainable Development that can be Obtained Using Census Data and/or a Combination of Census Data and Other Sources

Issue covered	Indicator	Census data that can be used to calculate this indicator	Relevance (extracted from the source document)
Sanitation	% of population using an improved sanitation facility	Type of sanitation facilities	Assess sustainable development, especially human health. Accessibility to adequate excreta disposal facilities is fundamental to decreasing the faecal risk and the frequency of associated diseases.
Drinking water	% of population using an improved water source	Access to drinking water	Access to improved water sources is of fundamental significance to lowering the faecal risk and frequency of associated diseases.
Access to energy	Share of households without electricity or other modern energy services. Additional: % of population using solid fuels for cooking	Type of energy for cooking and lighting	Lack of access to modern energy services contributes to poverty and deprivation and limits economic development. Adequate, affordable and reliable energy services are necessary to guarantee sustainable economic and human development. The use of solid fuels in households is a proxy for indoor air pollution, which is associated with increased mortality from pneumonia and other acute lower respiratory diseases among children, as well as to increased mortality from chronic obstructive pulmonary disease and lung cancer (where coal is used) among adults.
Living conditions	% of urban population living in slums	Data on population and type of materials used for roofs, walls and ceilings combined with other sources	This indicator measures the proportion of urban-dwellers living in inadequate housing conditions. It is a key indicator for measuring the adequacy of dwellings for the basic human need for shelter. An increase in this indicator is a sign of deteriorating living conditions in urban areas.
Vulnerability to natural hazards	% of population living in hazard-prone areas	Data on population combined with other sources, such as elevation maps, etc.	Measures the level of vulnerability in a given country, thus encouraging long-term, sustainable risk reduction programmes to prevent disasters, which are a major threat to national development.
Coastal zone	% of total population living in coastal areas	Data on population combined with other sources, such as elevation maps, etc.	Quantifies an important driver of coastal ecosystem pressure, and it also quantifies an important component of vulnerability to sea level rise and other coastal hazards.

Source: Based on: United Nations, 2007.

2. Waste disposal

The amount of waste generated, its composition and mode of disposal are important variables that are relevant for environmental analysis. Censuses usually only collect information on the method of waste disposal. Where household waste (solid or liquid) is dumped into streets, drains or streams, or burned (therefore creating emissions of carbon dioxide), especially in high density areas, the environmental consequences will be greater than in areas where such waste is either composted or collected through an organized sewerage system. But a collection system is not enough: It must be joined by a 'cleaning' or management system. If it is not, other areas (where the waste is disposed without treatment) will be affected.

This is, therefore, an important component of (local) environmental policies aimed at reducing toxicity and the volume of waste generated by the population at large, as well as increasing the coverage of households with waste collection and helping in the design of appropriate management of waste disposal.[4] The data are reported by municipal authorities, thus the results refer primarily to urban areas and waste collected by municipal trucks. While these components were included in Questionnaire 2008 on Environmental Activities by the United Nations Statistics Division (UNSD) and the United Nations Environment Programme (UNEP), the use of census data for this purpose is not mentioned. However, cross-referencing this information with census data would allow for a better measurement of the population covered by waste collection services.

3. Access to water and sanitation

Two indicators for monitoring progress of Target 10 of MDG Goal 7 (Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation) merit consideration. While indicator 30 refers to the proportion of the urban and rural populations with sustainable access to an improved water source, indicator 31 asks for an increase in the proportion of the urban and rural populations with access to improved sanitation (United Nations, 2008).

A comparison of average household sizes and the average quantity of water used per person per day with the availablity of water from the sources stated in the census can provide a basis to determine the sustainability of their use over time as the population continues to grow. Population and household projections could be used to demonstrate the imminence of an environmental crisis caused by the increasing need for water for drinking and sanitation. This is a key issue for adaptation to climate change.

4. Other relevant questions at the household level

Some countries may incorporate other questions that can help in identifying vulnerable groups and in the preparation of plans for adaptation to climate change. These may include questions on the type of energy used for heating, the availability of piped gas, the type of dwelling, the year of construction, the materials used in the walls, floors and roof, the availability of cars, trucks and other means of transportation for the household, the accessibility of IT, property tenure, location of toilet facilities, etc.

The use of the results from these questions for environmental and climate-change analysis

Despite the relevance of these questions, they are still used rather infrequently for the purpose of environmental studies.[5] One of the main uses seems to be for calculating the indicators for sustainable development that have been defined by the United Nations Division for Sustainable Development.[6] However, as can be seen in Table 12.2, those indicators are mainly utilized in identifying vulnerabilities and not necessarily for measuring emissions or, at the least, for characterizing subpopulations by their patterns of emissions.

In order to produce a change in this regard, there is a need for more analysis on the limitations as well as on the potential of census data for environmental and climate-change analysis. One of the reasons for the non-utilization of these data is that the number and types of questions included and the possible options for responses are limited. For example, the question on energy used for cooking does not cover how much energy is consumed or consider why there are variations in use between different population groups living in similar environmental settings. In addition, when electricity is used, households do not know how this electricity has been produced (hydro, nuclear, fuel combustion, etc.).

For these reasons, administrative records and household surveys seem to be more useful. Until now, surveys have been the most used source for this kind of analysis. However, censuses do have some main advantages: They cover the total population, including those living in households or collective residences, and they provide information on the whole country and allow for estimations for very small areas. This last characteristic permits a detailed analysis at the local level, which is impossible to do with household surveys. Thus, there is a need for triangulation of information from different sources: censuses, household surveys and administrative statistics. The combination of censuses and surveys is probably the better way to extract the best of both sources (coverage from censuses and better quality and details from surveys).

Finally, these data have also been used for measuring poverty, based on data on household's assets. The poverty indicator can be linked to other indicators, the better to express the vulnerability of different population groups.

Use of Census Data in Environmental and Climate-change Analysis

Population size and spatial distribution

The use of census data for environmental analysis has its starting point in linking population size to geography.[7] The Principles and Recommendations for Population and Housing Censuses of the United Nations (United Nations, 2008) provide a comprehensive overview of the census process, including the suggested questions to be integrated and the tabulations that need to be produced. In relation to environment, it concludes that:

> . . . *Population and housing censuses provide a powerful tool for assessing the impact of population on the environment, for example, on drainage basins and on water resource management systems. The spatial units for such a study may combine a group of local administrative areas. In this situation the availability of census databases with mapping capability (see paras. 1.126–1.128) is of great importance* (United Nations, 2008, p. 241).

In this regard, the use of census data is related to the 'resolution' of the data available (the size of the area in relation to its population). In their 2004 paper, "The Global Distribution of Population: Evaluating the Gains in Resolution Refinement", Balk and Yetman underline the fact that, in recent years, the country-specific average resolution of census data has increased. Significant improvements in access to a higher resolution of administrative data include: 1) the opening of National Statistical Offices (NSOs) and other providers of spatial data, including the fact that many NSOs allow for direct access to microdata;[8] (2) the beginning of awareness of and collaboration among providers of population and spatial data; and 3) the increase in capacity to manage, manipulate and process increasingly large population and geographic data sets. Alongside these developments, new efforts are being made to validate census data quality using satellite information systems. These positive changes do not eliminate the difficulties in comparability between censuses and therefore the difficulties for trend analysis, due to a lack of record keeping of census areas at NSOs.

Linking basic census data, such as population size, to the geographic area allows for the calculation of population density, a classic indicator for environmental study, particularly in urban areas. It also allows for the characterization of urban settlements: slums, sprawl, concentration and dispersion of the population. For adaptation policies, this indicator is still more relevant when it is combined with variables such as the type and quality of housing, source of water, energy, mode of waste disposal, patterns of occupational distribution and land use and tenure. It also helps to define the sustainability of the use of resources in particular locations and to highlight both environmental and related social vulnerabilities. Unfortunately, in most cases, this is the main and only use of population data for environmental analysis.

In urbanization studies, the indicator of density is one of the most relevant and most considered. A study on Chinese and Indian sites, for example, explores an alternative way to measure urbanization through density (Long et al., 2001). It includes the measurement of density (the percentage of the population living above and below a certain level of density and the percentage of occupied land under and above these specific densities) using census data for small areas. However, this methodology is considered to be more useful for making comparative studies. The authors suggest that ". . . the greater detail on the spatial complexity of each area measured at similar levels of spatial disaggregation could begin to supply the comparative data needed for ecological and other studies across many different societies and landscape".

Demographic dynamics, including household composition

The size and growth of population has been used to prepare the main Intergovernmental Panel on Climate Change (IPCC) emissions scenarios. However, there is a growing consensus that this is a very limited use of the information on population dynamics. Some studies (O'Neill et al., 2002; Dalton et al, 2008; Pachauri and Jiang, 2008) have shown the relevance of the composition and distribution of the population by sex, age, household structure and spatial distribution as key to understanding future changes in emissions.

But the importance of the size and growth of the population for adaptation and recovery plans should not be neglected. Specific age-sex categories evidently make varying demands on their immediate environments as they strive to ensure their livelihoods. Adaptation plans therefore need to consider the demographic and socio-economic characteristics of the population that could be affected by climate change.

Census data can be used in formulating these plans, taking care of the limitations of the data, particularly in regard to household composition, which also affects household surveys. De facto censuses can provide biased information on household composition, especially in cases of short-term migration. De jure censuses also have their own constraints. These factors need to be considered when using census data for this kind of analysis.

Identification of environmentally vulnerable populations

Censuses are an essential source for the identification of populations vulnerable to climate change and environmental disasters. This is the case for populations settled in coastal lowlands, which are at particular risk, including from rising sea level and flooding.[9] In addition to the geographic location, vulnerability is further exacerbated by income and other socio-economic and demographic factors, such as whether households are headed by women, men or children. Besides being already at peril from environmental change, dense populations in coastal zones can put a further burden on coastal ecosystems. Although this analysis seems to be an easy task, it is made difficult because censuses publish information by administrative areas that may not coincide with environmental areas (see Balk and Yetman, 2004).

In their article, "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones", McGranahan, Balk and Anderson (2007) assessed the distribution of human settlements in Low Elevation Coastal Zones (LECZs) around the world.[10] In order to calculate the population at risk and their international distribution in LECZs, the authors integrated spatially constructed global databases of population distribution, urban extent and elevation data, overlaying gridded geographic data, thus deriving totals of national populations in LECZs.

Linking demographic and socio-economic census data to environmental data

A good example of how census data can be utilized beyond their traditional use is presented in the recent publication, "Mapping a Better Future: How Spatial

Analysis Can Benefit Wetlands and Reduce Poverty in Uganda" (2009), by the Wetlands Management Department, Ministry of Water and Environment, Uganda, and the World Resources Institute. This report provides examples of the development of poverty maps for 2002 and 2005, based on estimations combining data from their 2002 population and housing census with estimations from the 2002–2003 and 2005-2006 household surveys, respectively. "The level of detail obtained at subcounty permits more meaningful spatial overlays of poverty metrics and wetland indicators [and provides] first insights into relationships between poverty, wetland status, and use of wetland resources" (p. 4-5).

Migration data

Censuses provide useful information for the measurement of internal migratory movements, particularly with regard to movements during the five years prior to the census (Rodriguez and Busso, 2009). Some countries have included questions with a shorter reference period, thereby obtaining information on rapid changes that can be linked to sudden recent environmental changes. The information obtained through the census can thus be used to monitor the changes in spatial distribution due to migration.[11] When associated with the environmental changes mapped through other sources, these trends would be of great value. In this regard, census data on internal and international migration can be used not only to measure the impacts on the environment but also as the main instrument to identify emerging new patterns of migration and settlement and land-use patterns in environmentally fragile areas or costal zones. Censuses, by virtue of their full coverage, present unique opportunities for analysis that cannot be matched by sample surveys.

Census data on spatial distribution could also be useful to identify emerging patterns of movement of people to new areas due to environmental changes. Bordt and Smith (2008) note that census data could be useful in showing additional settlement in new locations due to increased agricultural and forestry production in areas of currently marginal production.

Censuses can include questions on the reasons for migrating. This presents a great opportunity to show how census data on migration are uniquely suited for the identification of migration flows to and from environmentally fragile areas. In this regard, the census, by virtue of its full coverage, presents unique opportunities for analysis that also cannot be matched by sample surveys.

The use of census data on climate-change-induced disasters for planning, evaluation of impacts and recovery plans

The use of population data in preparing for and responding to natural disasters has been widely recognized. The "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters" (United Nations, 2005, pp. 6-27) underscores the need for a better understanding of the impact of hazards and the resulting physical, social, economic and environmental vulnerabilities, as well as their interactions. This requires the development of risk maps and systems of indicators of disaster risk and vulnerability at national and subnational scales.

In situations of humanitarian response, population data are keys to identifying the population in need of aid and where this population is located (National Academies, 2007). The availability of geo-referenced and updated population data is an essential component of timely emergency response, which requires an important investment in capacity building. Censuses provide the basic information to determine the number and characteristics of the "likely population at risk of natural disasters" (p. xi). However, censuses are only conducted every 10 years, at best; therefore, if these data are not complemented and updated with other sources (surveys, administrative records, etc.), their use could be limited. The publication of the National Academies emphasizes these issues in the cases of Haiti, Mali and Mozambique.

Recommendations

1. **What needs to be done to ensure that relevant questions are included in the censuses or that those usually included are adequate for current needs?**
   - The process of design of the questionnaire and the plan of analysis of census data must be gender sensitive and involve researchers and policymakers working on the mitigation and adaptation plans, in consultation with representative stakeholders.
   - Relevant census questions must eventually be added in order to measure the specific vulnerabilities associated with climate changes. In the case of a recent environmentally-induced disaster, specific questions should be added.
   - The categories for questions that focus specifically on environmental issues can be adapted to the national needs. These questions can be further focused by linking them to sociodemographic variables.

2. **What needs to be done to ensure that census data are collected, processed and made available to facilitate detailed analysis of very small areas (preferably environmentally homogeneous areas)?**
   - NSOs must commit to making census information available with the highest resolution possible. This will allow for a better definition of areas with higher vulnerabilities to climate-change-induced events.
   - NSOs should consider environmental areas in the definition of census areas.
   - NSOs should keep records of census areas to allow for inter-census comparisons.
   - Promotion of collaboration between different ministries and research centres, including professionals from different disciplines, ensuring the participation of gender and social development specialists.
   - Allow for the use of microlevel data and avoid a blockage of data users' access to them.

Box 12.1: Using Population Data for Measuring the Impact of Disasters: The Case of the ECLAC *Handbook for Estimating the Socio-economic and Environmental Effects of Disasters*

The Handbook for Estimating the Socio-economic and Environmental Effects of Disasters, produced by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) (2003), includes a section on the evaluation of the population affected by different kinds of disasters, including those that are environmentally induced. It presents a detailed methodology on how and when to use population censuses to determine the population that could be affected by disasters. Furthermore, the handbook shows the limitation of censuses and/or the projections derived from them for small areas in cases where censuses are outdated and important population mobility has taken place.

The manual provides methodologies on how to use population data, including censuses, to make an analysis of the human impacts of a disaster, including: 1) determination of the population with greater or lesser risk of being affected, identifying and defining profiles; 2) estimation of the demographic impact of the disaster, i.e., population and households likely to be affected by the event; 3) prevention and planning for action before the event occurs; and 4) generation of plans for evacuation or assistance during a disaster. Additionally, the social characteristics of a population are factors that increase or decrease the risk of harm. The level of education, socio-economic status, age structure and gender composition of the population, access to services, family structure, among other traits, influence the differential impact of the event.

Source: ECLAC, 2003, elaborated in collaboration with Alejandra Silva, CELADE-CEPAL.

3. What needs to be done to ensure that census data are made available, disseminated, analysed and used for national mitigation and adaptation policies?

- Create awareness: Advocate for a more extensive access to data for detailed analysis at the local level.
- Make census data useful by disseminating examples of good practices.

One of the most important areas of intervention in the implementation of these recommendations is capacity building.[12] A recommendation from the International Conference on Climate Change, Development and Official Statistics in the Asia-Pacific Region, held in Seoul in December 2008,[13] was that “the use of Geographic Information Systems and other spatial data infrastructure for the spatial analysis of official statistics should be improved and promoted” (Harper, 2008). This includes holding workshops on the development of spatial frameworks and the coding systems that have to be established to support these frameworks and building on existing census-based workshops to cover their use in the analysis of climate change (Harper, 2008).

Notes

1 The author thanks Debora Balk, Bruce Campbell, Sabrina Juran, Samson Lamlenn, George Martine, Ricardo Neupert, Gayle Nelson, Diego Palacios and Daniel Schensul of UNFPA, as well as Jorge Rodriguez and Alejandra Silva from CELADE, ECLAC, for their inputs and suggestions.

2 The same applies to documents from relevant agencies. See, for example, the presentation of the United Nations Environment Programme (UNEP, 2008).

3 The document, "Indicators of Sustainable Development: Guidelines and Methodologies," 3rd edition (United Nations, 2007), presents a list of 50 core indicators, which are part of a larger set of 96 indicators of sustainable development. Around 40 per cent of these indicators can be calculated (partially or totally) using census data. See a detailed list of these indicators in Table 12.2.

4 See: Questionnaire 2008 on Environment Statistics (United Nations Statistics Division). Website: http://unstats.un.org/unsd/environment/questionnaire2008.htm, last accessed 11 September 2009.

5 An example is the use of census data from Bolivia and Chile to determine the amount of lamps that could be used in a household based on the number of rooms and the lighting needed. This information was used to derive estimates of mercury disposal using different kinds of lamps (Camilla et al., 2009).

6 In other cases, the use of census data is even more limited. As an example of this, the International Atomic Energy Agency (IAEA), in collaboration with other international organizations, elaborated a framework of energy indicators. Despite the fact that some of these indicators could be calculated (or triangulated) with the information obtained from censuses, there is no mention of the possibility of utilizing the census as a credible data source. Among these indicators, the percentage of the population using electricity and using biomass could be calculated using census data, allowing for geographically disaggregated estimation.

7 The new *Handbook on Geospatial Infrastructure in Support of Census Activities* (United Nations, 2009) focuses on how the use and application of geospatial technologies and geo-referenced databases are useful tools at all stages of the census process.

8 If the microdata are available and geo-referenced, it is much easier to define geographic areas that are environmentally homogeneous. See: Balk and Yetman, 2004.

9 These also include those living in slum areas, on steep, eroded slopes, in valleys, in catchment areas, on arid lands, etc. All these present varying challenges in terms of the ways they can be affected by climatic changes and how they impact on the environment.

10 They estimate that 600 million people, of which 360 million are urban settlers, live in LECZs, accounting for 10 per cent of the world's population and 13 per cent of the urban population. LECZs, covering 2 per cent of the world's land area, are defined as the contiguous land area up to 100 kilometres from the coast that is less than ten metres above sea level.

11 See: Balk et al, 2009. In their study, "Mapping the Risks of Climate Change in Developing Countries", presented at the Population Association of America meeting in 2009, the authors use migration data from the 1991 and 2001 Censuses of India to identify migration flows and the fastest growing cities and towns.

12 As mentioned in the conclusions of the work of the Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Population at Risk (National Research Council of the National Academies):

> *At present, there are relatively few units, especially in developing countries, with sufficient trained expertise in both demography and geospatial tools and technologies. Improvements in training and commitment by the national statistical office (NSO) and other staff for each country to include both demographic projection methodology in local areas and the use of appropriate spatial administrative units in map form are essential. There are a number of mechanisms for building such capacity, the first of which is recognizing the importance of the skill sets required for disaster preparedness and response. The second is formalized training. Such training programs could be part of overall capacity building and funded by bilateral aid programs, such as USAID, or*

through broader country capacity-building programs, such as those supported by the World Bank or United Nations **(National Academies, 2007, p. 151)**.

13 Organized by the Korea National Statistical Office (KNSO) and the United Nations Statistics Division (UNSD).

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13

Understanding the Impacts of Climate Change: Linking Satellite and Other Spatial Data with Population Data

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Megan Todd

Introduction

An understanding of the impact of global climate change requires knowledge of who lives where. Accumulating sufficient knowledge about the locations and characteristics of the people who will be disproportionately and negatively affected by climate change, and, in particular, to identify the most vulnerable groups at risk, is a non-trivial undertaking. While data sets on climate patterns and data sets on populations exist, no single data set provides a complete picture of individuals and the communities and environments in which they live, making a comprehensive understanding of the impact of climate change on populations difficult. A more complete understanding can only be achieved by combining data from different sources, a practice that is increasingly possible, but still poses many challenges. Some important advances have been made: Satellite data are increasingly available, demographic data are increasingly spatially rendered and environmental data are increasingly being collected and produced with interdisciplinary inquiry in mind.

Data integration between two data sets that share identifying units can be straightforward, but data inconsistency within and between places may not be trivial. National statistical offices collect and report information in many different ways (United Nations, 2009), making, for example, a comparison of educational attainment among the residents of the neighbouring states of Texas, United States, and Tamaulipas, Mexico, impossible. This is true despite the fact that the United States and Mexico are quite similar in terms of census data collection. The complexities increase when definitions differ among data sources and even more so when there is a need to use data with dissimilar reporting units. The challenges that arise when combining population data—whether from censuses or surveys—with environmental data useful for describing or predicting climate-change hazards—whether derived from satellites or other spatial analyses—is the focus of this chapter. International agencies, national governments and local planners all need to prepare for climate change, and, in order to understand its potential impact on population, data must be organized and analysed in a spatial framework. This is true regardless of whether people live in cities or villages, though emphasis in this chapter will be given to the challenges of urban area analysis.

Climate modelling and physical geography help identify where climate-change-induced hazards are likely to occur, but in order to assess the resulting risks, human settlements and activities must be located in relation to these hazards. For example, it is essential to know to what extent people live in areas where coastal flooding and extreme weather events are expected to worsen and to what extent agricultural production is located in areas where water availability is expected to decline. In order to reduce risks resulting from climate change, it is most important that this spatially integrated information be available and put to use locally, as the impacts of climate change will be borne on particular localities. However, because of the global nature of climate and the likelihood that an increasing share of impacts of climate change will be felt in Africa, Asia and Latin America, it is also crucial to understand these risks globally.

Hazards faced by urban settlements are particularly important, not simply because urban areas concentrate people and their economic activities, but also because future population growth and economic growth are expected to be concentrated in these locations. The 2007 revision of *World Urbanization Prospects* (United Nations, 2008) projects that during the first half of the 21st century, the world's urban population will grow by about 3.5 billion, while its rural population will decline by about 0.5 billion. Since the spatial distribution of urban settlements is different from that of rural settlements, urbanization will play a role in how the burden of risks associated with climate change will shift in the future. Most urbanization will occur in Africa and Asia, but it is important to know more precisely where this growth will occur. Countering the increased population density inherent in urbanization, urban areas are also expanding spatially, thus reducing urban density. This phenomenon is most advanced in North America's sprawling suburbs but is also occurring in most other parts of the world (Angel et al., 2005).

This chapter draws heavily on the research of its authors, though it aims to comment more generally on the complexities of integrating spatial and non-spatial data to address dynamic, contemporary concerns. Much more could be said by the research and planning community that undertakes this type of interdisciplinary data integration.

What is meant by integration of data in a spatial framework?

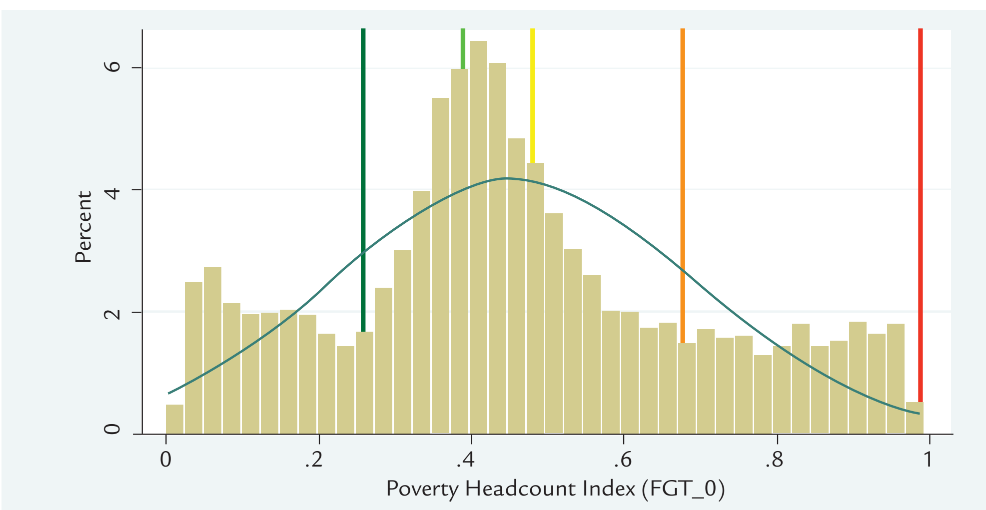
The urban and rural population and land at risk of sea level rise has been described elsewhere (Chapter 5; McGranahan et al., 2007). Here an example using poverty mapping data rather than population data is drawn on to demonstrate that population is not the only attribute that can be described in spatial terms. For example, one might wish to know the number of poor people living at risk of sea level rise—

i.e., within a 10-metre rise in elevation that is contiguous to the sea coast (the low elevation coastal zone or LECZ)—because the poor are expected to be more vulnerable to the untoward effects of climate change and the least able to adapt (Hardoy and Pandiella, 2009; Hardoy et al., 2001).

Figure 13.1 shows the frequency distribution of poverty among districts (third-order administrative units) in Viet Nam (Muñiz et al., 2008). Along the x-axis is the proportion of each district that is poor (ranging from 0 [no one] to 1 [everyone]). The y-axis indicates the percentage of districts that have each level of poverty. These data are derived from the World Bank's Small Area Estimation (SAE) of Poverty (Elbers et al., 2003, 2005; Minot, 2000; Minot et al., 2003), and though these units correspond to spatial boundaries for the administrative units, they were originally reported in a table (not shown). By matching this table of poverty attributes with corresponding spatial boundaries, these units can be rendered spatially, as shown in Figure 13.2 (Muniz et al., 2008). Without the map, it is not possible to recognize the spatial pattern of high poverty (shown in red) that is concentrated in central and northern Viet Nam. This type of data integration is relatively straightforward since the same administrative units are used as reporting units for both the table and the spatial boundaries. Even so, this type of integration requires common codes (or names) in each data set with which to link attributes (e.g., poverty rate) with spatial information. This linking is a simple function in geospatial and other statistical software packages, without which this task would be cumbersome and error-prone.

Additional spatial data integration in Viet Nam not only shows that some units are coastal, but also allows the land area and population at risk of seaward haz-

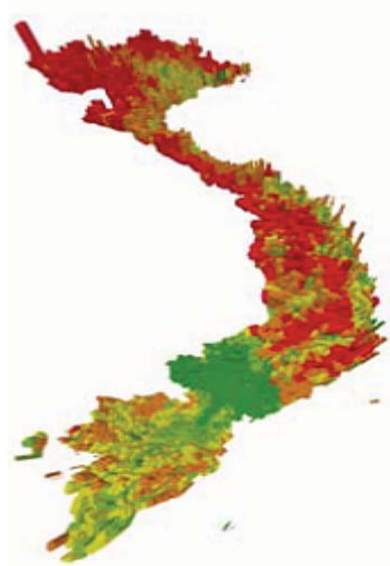
Figure 13.1: Frequency Distribution of Per Cent Poor in Each District, Viet Nam



Note: The coloured lines from green to red indicate country-specific quintiles of poverty rates by district (third-order administrative unit).

Source: Muñiz et al., 2008.

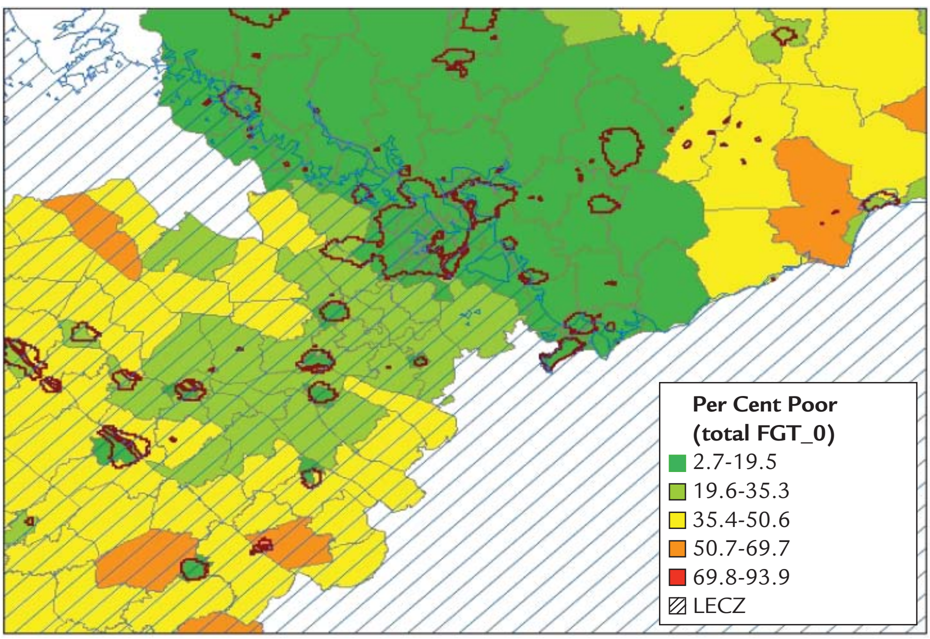
Figure 13.2: Poor in Each District, Viet Nam



Note: The shading from green to red represents country-specific quintiles of poverty rates by district (third-order administrative unit), and the extrusion represents numbers of poor persons (expressed in tens of thousands).

Data source: Minot, 2000.

Figure 13.3: Per Cent Poor, LECZ, and Urban Footprints, Viet Nam



Data sources: Minot, 2000; Muñiz et al., 2008; and McGranahan et al., 2007.

ards to be calculated according to a set of systematic characteristics accounting for coastal proximity and elevation. Figure 13.3 shows the data layers: poverty level in green to orange hues, the LECZ in blue hatching (McGranahan et al., 2007) and the urban footprint, derived from satellite imagery of night-time lights (from the Global Rural-Urban Mapping Project [GRUMP]), outlined in brown (described below and in Balk, 2009). In this view, the LECZ covers a large portion of the land area, illustrating that, in this low-lying delta, it would be a huge underestimate to define the

Table 13.1: Estimates of Urban Poor at Risk of Climate Change Coastal Hazards, Viet Nam

	% Poor	Number of Poor	Number of 1 km cells
Non-LECZ City	26.6	342,030	79
Cities with any land area within the LECZ			
LECZ City, Non-LECZ Land	20.30	413,623	36
LECZ City, LECZ Land	28.0	2,112,987	131

Data sources: Minot, 2000; Muniz et al., 2008; McGranahan et al., 2007.

vulnerable population as only those residing in districts bordering the sea coast. Figure 13.3 also makes it possible to distinguish urban population and land (within the GRUMP urban footprints) from the rural (outside the footprints).

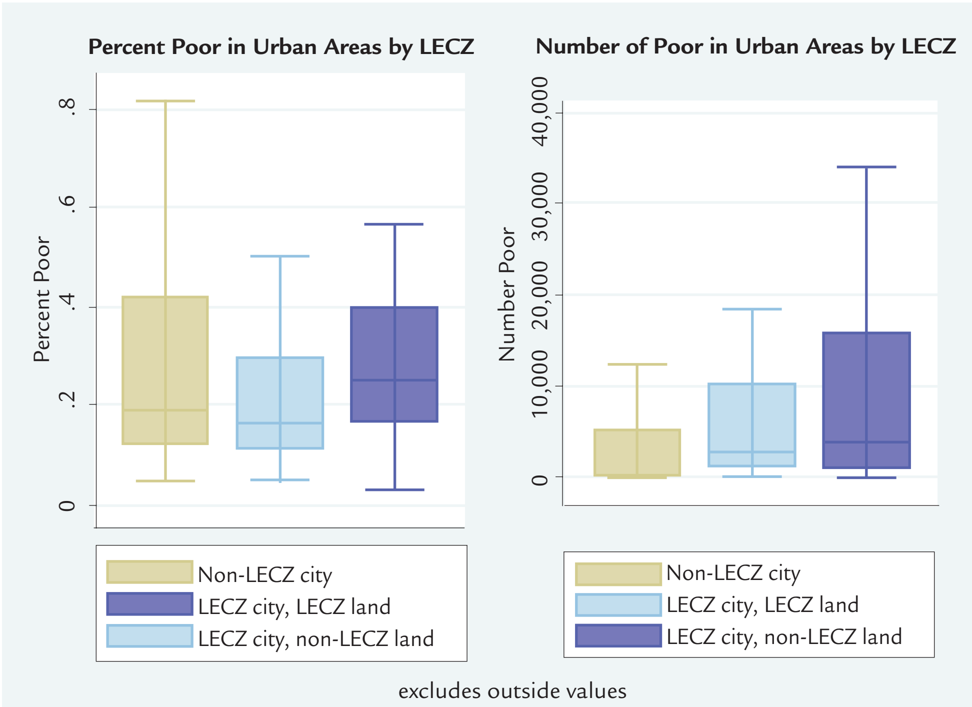
From this integration, it is possible to summarize populations at risk, as in Table 13.1 and Figure 13.4. Table 13.1 summarizes three types of exposures: persons who live in cities entirely outside the LECZ, persons who live outside the LECZ but in cities with some land area in the LECZ and urbanpersons living in the LECZ. Vulnerability—here expressed as poverty—is indicated two ways: by the proportion of the exposed population that is poor and by the total number of exposed persons who are poor. Though the poverty rates are similar among residents of the LECZ and residents of non-LECZ cities, those living in the LECZ outnumber poor people living in non-LECZ cities by five to one. Figure 13.4 shows this graphically. Only data integration in a spatial framework makes these estimates possible.

Table 13.2: Comparison of Spatial and Tabular Approaches to Estimating Urban Population Distribution: Population Density in the Urban Low-elevation Coastal Zone

Country	Average Resolution of Underlying Census Data (km)	Distribution of Urban Areas	Urban LECZ Population ÷ Urban LECZ Land Tabular (National Aggregate) Estimates	Urban LECZ Population ÷ Urban LECZ Land Spatially-derived Estimates	Ratio of Tabular to Spatial Estimates
Viet Nam	8	Most in LECZ	4,489	3,317	1.4
Philippines	14	Many in the LECZ	13,284	3,636	3.7
Brazil	29	Biggest ones in the LECZ	11,523	939	12.3
South Africa	1	Most not in the LECZ	92,413	1,463	63.2
Congo, Democratic Republic of the	184	Most not in the LECZ	146,533	102	1,431.2

Data sources: Minot, 2000; Muniz et al., 2008; McGranahan et al., 2007.

Figure 13.4: Percent Poor and Number of Poor in Urban Areas, Viet Nam



Data sources: Minot, 2000; Muñiz et al., 2008; McGranahan et al., 2007.

Data integration challenges in general

Estimates that are derived strictly from national-level aggregates and that do not formally integrate demographic and environmental data using a spatial framework are likely to produce highly inaccurate estimates. Neither cities nor persons (regardless of whether they are urban or rural residents) are uniformly distributed across national territories. New analyses have identified some patterns of city and population distribution vis-à-vis geographic characteristics. In a global study, McGranahan et al. (2007) found that LECZs are disproportionately urban compared to other ecozones such as drylands. Further, they found that 75 per cent of all countries have their largest city in the LECZ. In Table 13.2, two estimates of population density in urban areas in the LECZ are examined for five countries. Estimates based on national-level aggregates that are expressed only as tables (tabular estimates) are compared to estimates based on overlaid spatial data comprising administrative, night-time lights and settlement attribute data (see below and Balk, 2009, for more on GRUMP methodology). The five countries in Table 13.2 vary in the spatial resolution of their census data; low numbers indicate many smaller census units. Viet Nam is an example of a country with most of its urban areas (and much of its land area) in the LECZ.

Scale and Resolution

In order to produce robust urban estimates, data must be spatial and must be of sufficient resolution and scale. Recent efforts have produced basic descriptions of the population distribution of urban areas in a spatial framework (Balk, 2009; Montgomery and Balk, forthcoming). These efforts are an important departure from prior approaches: Population estimates for cities can now be rendered in physical space. However, there is currently no spatial database that allows for the estimation of changes in urban population and area at a global scale. While moderate- and high-resolution data permit change estimation at the scale of a city or a handful of cities, much work in methodology, data processing and validation remains to be done before a globally consistent, spatial-temporal view of urban areas exists (Small, 2005).

While spatial data are necessary, they may not be sufficient: The properties of the spatial data matter. Especially when evaluating spatially-specific urban population data with respect to environmental data, resolution must be at a scale that is appropriate for urban-area-level analysis; that is, the unit of analysis must be fine enough to adequately capture variation within and around the urban area. Currently, the resolution of most geophysical data—such as the historical climate record and future climate predictions, as well as many disaster databases—is much coarser than that of the city, preventing meaningful analysis of these geophysical data at the city and sub-city scales. Just like national-level aggregates, coarse spatial data misleadingly distribute place-specific characteristics over a too-large

Table 13.3: Resolution of Selected Spatial Data and Size of Average Urban Areas

East-West Arcs		Distance per side (km)	Area (km^2)
		at equator	
5 degrees	Climate models		
1 degree		111.32	12,392.1
0.5 degee	Rainfall, precipitation models	55.66	3,098.0
	Average urban area, 1 million + persons		**1,650.0**
5 minutes (0.083°)	Gridded Populatin of the World (GPW) v1	9.30	86.5
	Average urban area, <1 million persons		**70.0**
2.5 minute (0.042°)	GPW v3	4.65	21.6
30 arc-sec (0.0083°)	GRUMP, SRTM, Ecozones	0.93	0.9
1 arc-sec (0.000278°)	Landsat	0.03	0.0009
	Quiksat, Ikonos	0.001	0.000001

Note: Average urban area size is determined by GRUMP for cities in Africa, Asia and South America. Distance and area calculated at the equator.

region. If the true characteristic is variable across the areal unit of analysis (the 'cell' in geophysical parlance), coarsely resolved data will mask intra-cell variation.

Table 13.3 shows the resolution of some key environmental data and the average size of urban areas in Africa, Asia and South America. Urban localities are much smaller than, and would be subsumed by, the cells of many spatial data sources. This means that no variation in these environmental data would be observed within an urban area, a presumption that is clearly false. High- and moderate-resolution satellite imagery can often provide a smaller-celled view into urban areas, but these images typically show vegetation and other features rather than climate data. Appropriate use of integrated data critically depends on issues of scale and precision.

Satellite data: More than just a pretty picture?

Satellite data may be the most objective means by which to systematically identify urban areas (Potere and Schneider, 2009). At a local or regional scale, these data may be used to identify change in built-up area or land use. Inexperienced users of satellite imagery must remember that without expertise an image is not much more than a pretty picture. It takes considerable knowledge to evaluate, interpret and classify satellite data (Small, 2005). With expert evaluation, satellites can reveal a great deal about vegetation, permanent lights and built-up areas, but these data are not ready to use outside of a spatial framework. It usually takes interdisciplinary teams of researchers to translate satellite data into outputs that can be integrated with census-type population data (Small and Cohen, 2004).

Satellite data have some shortcomings. The data never provide the city names, identifying codes or statistical reporting concepts (e.g., city proper, urban agglomeration) that are commonly attached to population censuses. This may not be an important shortcoming when studying a single location, but it is a significant limitation when working across many localities or at a regional or global scale. Satellite data are costly to process, and many types are prone to cloud cover, which obscures the features of interest. Additionally, analysis is more subjective than the typical social scientist is used to.

Satellite data, however, also have unique strengths. Unlike surveys, censuses or even administrative boundary data, for which the cost of collection tends to be borne by countries, the cost of satellite imagery is borne in large part by the data collector. (Sometimes, a portion of that charge is passed on to data users as fees.) The data may be supplied by international experts or their space-borne technology. This means even countries with limited resources can be studied with high-quality data.

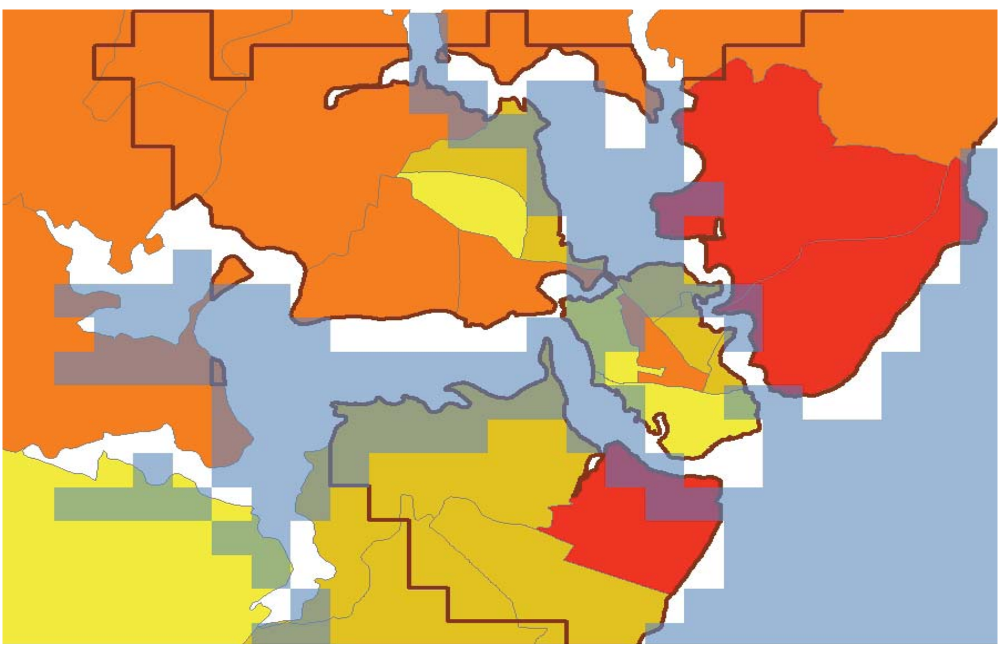
Although some satellite data can be a time series, few global studies of integrated data are. In Chapter 5 of this volume, a study is described wherein an integrated data set linking satellite-derived urban footprints to names and population values is constructed, but it does not have time-varying spatial data for cities. Though much has been learned from data integration, those lessons have not resulted in an automated process for continued future integration. Integration of disparate data sets is—and should be expected to remain for the foreseeable future—a highly labour-intensive enterprise, even with considerable programming aids.

Demographic data: More than just head counts?

The global demographic record is built from a variety of data sources: national censuses, vital registration data and household survey data. Sometimes censuses or even vital registrations are rendered at a fine sub-city resolution, but surveys typically are not. Survey data tend to be relied on mostly in countries with weak census or vital registration systems. How to best piece together these multiple and fluid data types to build a fuller record for city (and sub-city) demographic data at a global scale is an open question.

The demographic record has its own shortcomings (see Montgomery et al., 2003). There is no globally consistent or systematic set of demographic estimates for the world's cities, except for the most populous cities and those large enough to be comprised of standard census reporting units (such as counties or districts). For most cities of the world, there are no data on age distribution, fertility, mortality or migration. Even when this type of information is available at the city scale, it is rare that it also exists for neighbourhoods within cities (Weeks et al., 2007). In some cases, urban estimates exist that are aggregated to the national or first-order subnational units, but this record cannot be translated to specific cities or even classes of cities based on their population size.

Figure 13.5: Mismatch Example, LECZ and Per Cent Poor, Kenya



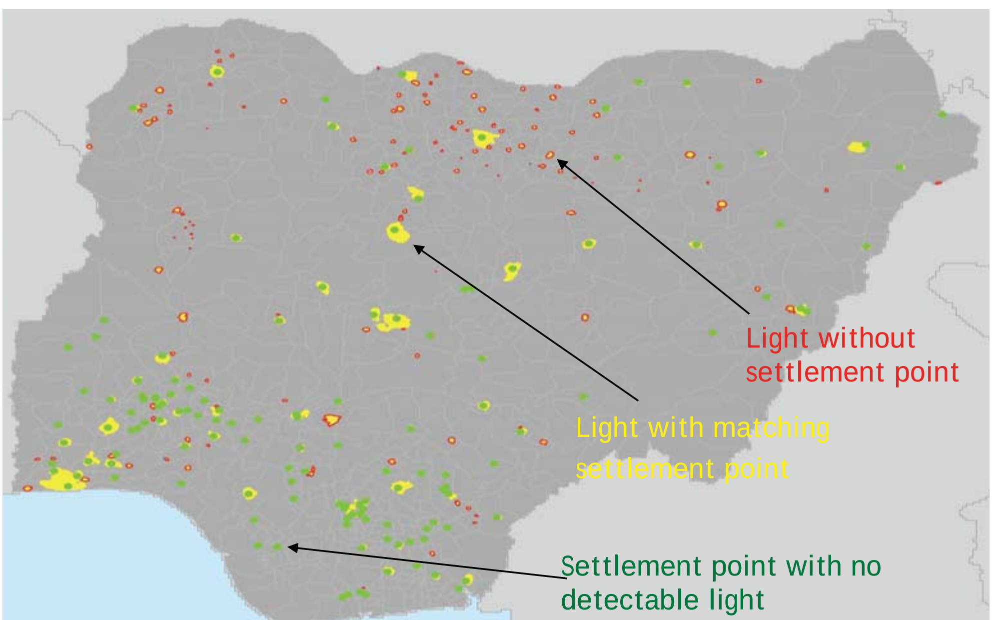
Data sources: CIESIN et al., 2008; Ndeng'e, 2003; McGranahan et al., 2007.

Issues that arise upon integration

The precision and accuracy of the various data layers matter, and small differences may be amplified when different data sources are integrated. Figure 13.5 shows how small differences in the precision of the administrative boundary-based coast line of Kenya (data initially supplied by the Kenyan National Statistical Office [Ndeng'e, 2003]) and the LECZ layer (from Shuttle-Radar Topography Mission Digital Elevation data) result in evident gaps between the land (yellow-red hues depicting the distribution of poverty) and sea (in blue). White space shows the mismatch. This can result in the mischaracterization of the population at risk of coastal flooding and other seaward hazards. Whether one or both data sources are inaccurate is a matter yet to be determined. All data integration is at risk of this type of mismatch. Even within countries, different data users might modify boundary data to suit their needs. Some agencies wish to include water bodies in jurisdictional boundaries while others wish to omit them. Sometimes there is agreement on how to reconcile multiple sets of boundaries, but often there is not.

To study urbanization, the Global Rural-Urban Mapping Project (see Balk, 2009) uses night-time lights satellite data as a proxy for urban areas, combined with population settlement data. While night-time lights are the most systematic urban footprint, it is evident that, in some locations at least, they are an imperfect proxy for urban areas. Lights can be seen where there is no identifiable settlement, and some settlements have no corresponding light. Figure 13.6 shows these mismatches. GRUMP accepts the latter type of location and estimates a settlement size based on other known settlements, but disregards lights without points, as these are believed

Figure 13.6: Night-time Lights, Nigeria



Data source: CIESIN et al., 2008.

to be unlikely to be true settlements (e.g., lights produced by oil flares in oil-producing countries are not permanent human settlements). It is, however, possible that some lights without points were omitted from the national statistical reporting of settlements for other reasons (such as political ones) and that the lights are a means for challenging census results. Either way, it is integration that opens up these important inquiries for each analyst to adjudicate for him- or herself.

Every data integration effort will require some subjective judgement on the part of researchers. In addition to the examples above, the authors of this chapter have faced several puzzles. For example, if two settlements are identified with near-identical geographic coordinates, and have names that match but for one letter, are they the same city or different cities? If a settlement falls outside an observed light, should that settlement be considered part of the same urban area as the light, given the spatial measurement error of the lights (about 3km)? Should settlements falling within 3km of a light be assigned to the light? (Perhaps a band of 3km of the lights on both sides of the light boundary should be treated as less sure matches.) If a light appears very near the border of two countries, is the precision of the country boundary great enough to definitively place the light in one country? Does a many-to-one match between settlements and urban areas make sense if the settlements are meant to represent a relatively large metropolitan area? The answer to these dilemmas may depend on the purpose of the study.

Most important, when subjective data integration decisions are made, a transparent record of these decisions and the reasoning behind them must be kept, and an effort must be made to develop a systematic approach for analogous issues. Both of these concerns can be addressed by programming the data integration process in statistical software such as Stata or SAS. Python is particularly useful for working with spatial data, as it can create output easily read by map making software such as ArcGIS. Careful, well-documented programming is crucial to a study's repeatability and transparency, a point that cannot be made strongly enough.

Conclusions

It is not known precisely where climate change will occur. But to prepare for those changes, both climate-change and social-science researchers need to adopt a spatial framework of analysis that is attentive to current and future population concentrations in urban areas. The integration of these data is essential to understanding the risks that populations face from climate change.

Understanding the construction of integrated data is essential for data users, even for those users uninvolved in the integration process. Development and planning efforts for improvements in urban drainage or sanitation, for example, require both spatial and population data; so does projecting where migration will swell the populations of towns and cities that lie in the path of risk. National economic strategists need to be made aware of the implications of locating special economic zones in sensitive areas and of promoting coastal development in what will become environmentally risky sites. Secondary data users, such as developers and planners, must inform themselves of methodological decisions made in the construction of any integrated data sets, because these decisions will impact the interpretability—and conclusions—of analyses resulting from these data.

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14

Population Data for Climate Change Analysis

Hy Dao
Jaap van Woerden

Multiple Data for Climate Mitigation and Adaptation Analysis

Climate change analysis covers a myriad of complexities related to definition issues (e.g., the categorization of urban/rural areas); temporal and spatial scales (global, regional, national and community); the measurement of consumption-based versus supply-based emissions; definitions of basic information such as coastlines and boundaries; and omissions in the production and dissemination of statistical data, among many others. Data on population are at the centre of most of the climate-change analysis to be carried out, including climate scenarios, as well as of analyses of vulnerability, impacts and adaptation. Population, as both a driver and a subject of climate change, is part of the issue, but it is also part of the solution through actions that societies and individuals can take for mitigation and adaptation.

From previous global assessments, it appears that responses to the challenges of climate change require the use of multiple sets of data for multiple types of analyses of both the mitigation and the adaptation dimensions. Therefore, one of the foremost challenges in understanding the linkages between population dynamics and climate change lies in identifying, collecting and integrating data on multiple thematic, temporal and spatial scales.

A community of researchers is working on the integration of satellite imagery, climate modelling and socio-demographic data in order to understand local vulnerability in many parts of the world. These efforts, however, are under-funded and are being carried out with less than optimal coherence and coordination within the United Nations system to have a holistic global picture.

United Nations support for improved data streams and technical assistance are essential for making these connections. United Nations agencies must advocate for responses that include the characterization of population trends and support the data collection, research and analysis at the global and country levels that are necessary to ensure that policy responses are evidence-based. Encouraging and supporting the timely release of high-quality census data is also an important role for global institutions.

Access to global data has improved significantly in recent years, mainly in response to the development of global integrated environment assessments. Several data portals at the United Nations, the United Nations Environment Programme (UNEP), the World Bank, the Food and Agriculture Organization, etc. provide very valuable data sets at the country and regional levels. As the global picture is becoming clearer, more detailed and local information is now required in order to design appropriate concrete mitigation and adaptation measures.

This chapter will briefly review the main data needs already identified in existing assessment reports before addressing the definitional, spatial and temporal aspects of population data in a wider setting of climate-change analysis.

Overview of Climate-related Data Issues

Mitigation and adaptation data

The issue of climate change has now moved to the top of the environmental policy agenda. The entire United Nations system is committed to supporting Member States as an effective, inclusive and credible partner in mitigating and adapting to climate change. Thus, mitigation and adaptation to climate change have become global priorities. UNEP certainly is no exception to that. With the release of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) and the Bali Action Plan adopted by the United Nations Framework Convention on Climate Change's (UNFCCC) Conference of the Parties 13, UNEP was able to finalize its Medium Term Strategy (MTS) with six thematic priorities topped by climate change. Several other priority areas are very much related to climate change, such as ecosystem management, disasters and conflict, resource efficiency and environmental governance. Four major themes related to climate change were identified: adaptation, mitigation, science and communication.

While population is a major driving force of climate change, it receives relatively little attention and is often treated as an external factor. There is, however, an upstream relationship between population and climate change: More people mean more emissions, more production and more consumption. Most rapidly growing populations currently have very low per capita greenhouse gas emissions, but per capita emissions and populations are increasing rapidly in much of the world, and the developing world is becoming a substantial contributor to climate change. While industrialized countries have contributed the most to the accumulation of emissions in the atmosphere, emissions in the developing world will grow significantly faster in coming decades—because of population growth, economic growth, a high dependence on fossil fuels and a relatively high energy intensity:[1] "[T]he effect on global emissions of the decrease in global energy intensity (-33%) during 1970 to 2004 has been smaller than the combined effect of global income growth (77%) and global population growth (69%); both drivers of increasing energy-related CO_2 emissions" (IPCC, 2007).

Table 14.1: Requirements for Mitigation and Adaptation

Climate-change mitigation data needs

General	GHG emission trends (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6);
	Population, urban and rural, poverty, migration.
	Land-cover and land-use change, land degradation.
	Gross domestic product (GDP)/Purchasing power parity (PPP), sector value added, household consumption.
Energy	Energy use, supply and intensity (by sector), production and use of renewable energy (solar, wind, hydro, geothermal, biofuels), nuclear power, natural gas, coal, oil, gas.
Transport	Number of hybrid and cleaner diesel vehicles, transport volume by rail/road/water/air/non-motorized.
Buildings	Use of energy-saving bulbs, improved cook stoves, isolation.
Industry	Material recycling and substitution rates, heat and power recovery, etc.
Agriculture	Afforestation, reforestation, forest management, avoided deforestation, harvested wood product management.
Waste management	Landfill methane recovery, composting of organic wastes, waste disposal, treatment and recycling, waste water treatment.
Policies	Climate policies and measures, carbon prices, emission trading, budgets and expenditures for climate policies, meteorological monitoring.

Climate-change adaptation data needs

Water	Water availability and droughts in tropics, high latitudes, mid-latitudes and semi-arid low latitudes;
	Number of people exposed to (increased) water stress.
Ecosystems	Number and risk of extinction.
	Coastal wetlands, coastal areas.
	Coral bleaching.
	Species range shifts and wildfire risk.
Food	Productivity of cereals at low-mid-high altitudes;
	Local impacts on small holders, subsistence farmers and fishers.
Coasts	Number of people exposed to coastal flooding each year.
	Damage from floods and storms.
	Average rate of sea level rise.
Health	Changed distribution of some disease vectors;
	Burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases.
	Morbidity and mortality from heat waves, floods and droughts.
	Burden on health services (expenditures).

Source: IPCC, 2007.

There are also downstream relationships, through the link between poverty and vulnerability to the effects of climate change, changes in water supply and availability, internal and cross-border migration and potential conflicts and disasters.

In order to assess climate change mitigation and adaptation opportunities, and address the interlinkages, a whole range of scientific data and indicators are needed. The requirements for mitigation and adaptation specified in the IPCC Fourth Assessment Report (AR4) are presented in Table 14.1 (IPCC, 2007).

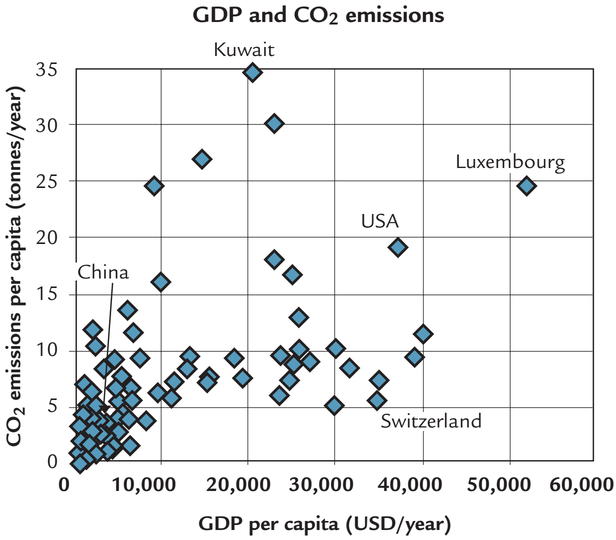
Many of the worldwide climate-related data and indicators are collected through scientific measurements, e.g., temperature, precipitation, radiation and so forth. Others are compiled by international agencies on the basis of statistical surveys, often using national statistical sources and, more recently, remote sensing data. This is the case, for example, for population (United Nations Population Division), gross domestic product (United Nations Statistics Division [UNSD] and the World Bank), forestry and agriculture (FAO), health (World Health Organization [WHO]) and energy (International Energy Agency [IEA]), among others.

But various additional data need to be collected and/or compiled to adequately address climate-change adaptation and mitigation issues. The list of these data and indicators, for which national statistical offices can play a role in regularly collecting information, includes:

- Air emissions reporting, most notably in developing ('non-Annex 1') countries, and including underlying energy and activity data;
- Data on infrastructure development (roads, etc.) and the amount of building (housing, offices, industrial plants, etc.);
- Use of renewable energy sources;
- Use of energy-saving technology (bulbs, building insulation, hybrid cars, etc.);
- Eco-labelling and use of certified products (such as certified wood);
- Use of emissions trading and climate compensation schemes (including carbon pricing);
- Volume data on transport modes (motorized and non-motorized);
- Material recycling and substitution;
- Water use;
- Land/vegetation cover and ecosystem areas (wetlands, coasts);
- Species extinction, migration patterns;
- Harvest and crop production (wheat, maize, rice, etc.);
- Mortality and morbidity (specific diseases);
- Number and extent of hydro-meteorological disasters (floods, fires, storms, droughts, heat and cold waves) and the resulting damage;
- Budgets and expenditures on health services, disaster prevention and damage repair (recovery).

These data would allow the international community to better assess the causes and impacts of, and the responses to, climate change at the global, regional and

Figure 14.1: GDP and CO_2 Emissions



Linking population with economy and GHG emissions:

What is the relation between GDP and CO_2 emissions?

Will it remain the same in the future?

Data source: GEO Data Portal http://geodata.grid.unep.ch

national levels. Nevertheless, because of the costs and efforts required to acquire and update these data, their relevance must be clearly defined. From an empirical point of view, the spatial and temporal completeness of existing data must be assessed, since many sociodemographic indicators are still incomplete. For instance, figures on education, poverty and governance are only available for a limited number of countries, and past data, as well as projections, are difficult to obtain. The redundancy of data also needs to be evaluated. For instance, it is well known that GDP and the Human Development Index are highly correlated. Therefore, the simple use of the more complete GDP data could be enough (and more efficient) as a proxy for the study of development levels. Some data are easily accessible because of well-established and standardized observation processes (economic accounts, environmental measurement networks, national statistics), whereas others are more difficult to acquire because they come from irregular surveys and subjective perceptions (e.g., the governance indicators). In parallel to these pragmatic considerations, and more fundamentally, data must fit into a properly defined theoretical model in order to be fully relevant as indicators for climate-change studies, as will be discussed in the next sections.

Framing data and indicators

Definitional problems

Is GDP a mitigation or adaptation indicator?

It is not always clear how to categorize data into mitigation, impact or adaptation indicators nor is it clear how to draw the line between these three groups. For instance, GDP is listed above as a mitigation variable, but it is neither directly nor linearly linked to greenhouse gas (GHG) emissions, in particular to CO_2 emissions (see Figure 14.1). This relationship is influenced by other factors such as the technology available, the structure of the economy, the level of imports/exports and the nature of consumption by households, among others. Furthermore, decoupling economic growth and environmental pressure is an explicit objective of some environmental policies (e.g., the Environmental Strategy of the Organisation for Economic Co-operation and Development [OECD]). The fact that GDP is not the only relevant driver of GHG emissions is nothing new, but GDP is still considered a main, or at least indirect, driving factor in many climate-change assessments.

On the other hand, GDP can be used to assess the impacts of climate change on the economy: Weather-related disasters can destroy livelihoods and infrastructure, affect the working population through diseases, thus diminishing the production capacities of a territory. Finally, GDP can be seen as a vulnerability proxy since weaker economies might have more difficulties in adapting to climate change and to its related effects. Large and diversified economies have more power to absorb the shocks of disasters than small and single-sector-based economies.

What is population?

The same questions apply to population as a driver of GHG emissions. The number of people as such might not be the main determinant of consumption and emission levels. The structure of households (size, age and composition) and their consumption habits may have a strong role (O'Neill et al., 2002). Therefore, additional demographic variables (along with their projections for the next decades) may be needed, at various spatial scales, to properly estimate future emissions patterns.

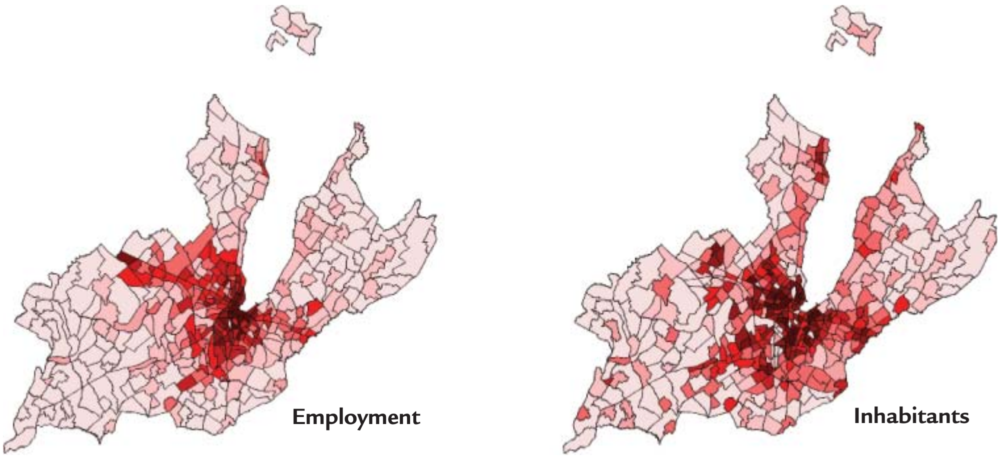
Population is impacted by climate change, and it will act to adapt. In assessing potential impacts, the traditional residential approach to inventorying population may not always be the most relevant one. In the course of a normal week or day, people are often not at home. They work, travel, shop and engage in leisure activities in many different places. Population maps based on census data show a specific spatial distribution that is representative of certain time periods and population groups (e.g., non-active versus active). For risk management, it also necessary to complement this view with other data such as those on working and shopping locations, which are more appropriate for locating people during the daytime. Figure 14.2 shows the difference between employment and residential locations in Geneva in 2000.

In terms of adaptation, additional data on the structure of the population might be useful. Median age, age dependency ratio and life expectancy are important indicators of vulnerability as well as of the capacity of a territory to react to future shocks. Ageing, for example, is occurring in industrialized countries, but it might be counterbalanced by an expected higher life expectancy in the next decades (Johansson et al., 2002).

Multi-dimensional approaches

The preceding remarks underline the importance of placing each indicator into context, if not into a structured model. Since the 1970s, studies on the relation-

Figure 14.2: Population, Geneva, 2000, from Employment and Residential Data



ships between people and the environment have progressively made use of more and more sophisticated models for understanding the nuances of these linkages, e.g., in the fields of land-cover/land-use change or climate change (de Sherbinin et al., 2007). The development of population-environment theories was also made possible by the increased availability of data at different temporal and spatial scales. These models combine, in an integrated way, knowledge on both the bio-physical and the socio-economical dimensions of the earth system from multiple disciplines. Based on quantitative and qualitative data, the models are subject to various levels of uncertainties which have to be expressed. They are abstract and simplified views on the states and processes of the real world, which can (and should) support information and decision-making.

One famous example of a simple model is the "I = PAT identity" (impact [I] = population [P] x affluence [A] x technology [T]), introduced in the early 1970s. The I = PAT equation was applied in the field of climate change, in particular in the IPCC Special Report on Emissions Scenarios (SRES) (IPCC, 2000), for expressing emissions (e.g., CO_2 emissions) as a function of population, income and energy intensity:

$$CO_2 \text{ Emissions} = \text{Population} \times (\text{GDP}/\text{Population}) \times (\text{Energy}/\text{GDP}) \times (CO_2/\text{Energy})$$

More complex examples include global scenario studies, such as the IPCC SRES, the United Nations Millennium Ecosystem Assessment or the *Global Environmental Outlook* (GEO), the 'flagship' report of UNEP. Since its first edition in 1997, the GEO has developed an increasingly integrated approach to environmental analysis, making use of indicators and reporting. This has resulted in a whole range of global, regional, national, local and thematic reports as well as various databases, information and learning tools and other resources. This type of environmental assessment is a key vehicle for promoting the interaction between science processes and the various stages of the policy- and decision-making cycle. These studies underpin decision-making by UNEP's Governing Council, the various Multilateral Environmental Agreements, regional ministerial environmental forums, the private sector and national and local authorities.

The methodology of the GEO Integrated Environmental Assessment (IEA) report series is now well established and documented.[2] It follows a multi-thematic, multi-region and scenario-based approach. It is adapted and applied to various spatial scales, from the global to the regional, national and local/urban (e.g., GEO-Cities reports). This series of studies is based on the model, "Driving Forces – Pressures – States – Impacts – Responses" (DPSIR), a framework for analysing the interactions between society and the environment. DPSIR, an extension of the previous OECD pressure-state-response (PSR) model, enables a formal and causal analysis of factors that have an influence on the environment. Although sometimes seen as too mechanistic, the DPSIR framework helps to structure data and indicators on various dimensions of environmental problems. These data are the foundation of subsequent analyses. Networks of partner institutions around the world (namely, the GEO collaborating centres) have provided data and interpretations at various levels of analysis. These have been disseminated through global and regional GEO Data Portals,[3] which have found users far beyond the GEO partners.

Policymakers often face a growing list of environmental challenges. Many of these are complex: They have a direct or indirect effect on human well-being and require an enhanced understanding to support effective response measures and actions. Integrated environmental assessment and early warning approaches have strengthened the harmonization and the accessibility of reliable environmental data and information for improved policymaking at different levels. Data portals have considerably facilitated the practical use of data by means of graphs, tables or maps or by providing for the downloading of data sets in GIS compatible formats.

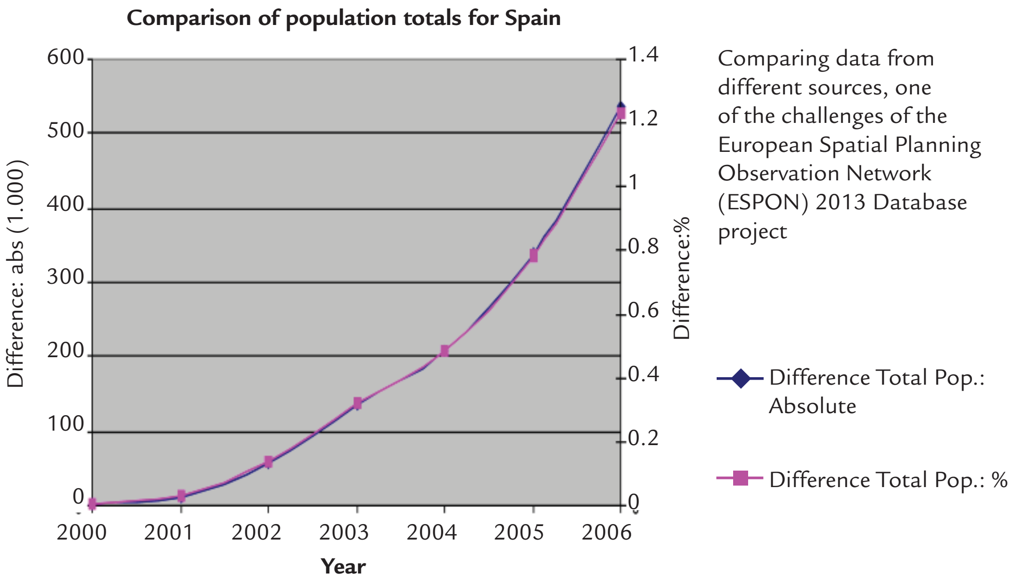
Today, there is a greater investment by the international community and governments in environmental assessments and early warning information services, in terms of both human and financial resources. However, despite the availability of considerable information on the state and trends of the global environment, there is a lack of adequate and relevant data, and there is a lessened capacity of monitoring and data collection systems, especially when detailed, up-to-date and complete data are needed at various scales.

Data needs for different scales of analysis

While a vast amount of data and indicators is already available for analysis and information purposes, more data of high quality are needed. National statistical offices can play an important role in collecting new and additional data and—together with the United Nations and other agencies—in strengthening and harmonizing existing surveys and other data collection activities in the area of adaptation to and mitigation of climate change.

In order to be scientifically credible and policy relevant at the same time—which do not always go together—it is of critical importance to work with sound,

Figure 14.3: Population Data Discrepancies between European and United Nations Data, Spain, 2000-2006



reviewed data, preferably from official records. National statistical offices and international agencies play an equally important role in collecting and harmonizing census data. Additional research and modelling are needed to assist with data harmonization, analyses of interlinkages and the development of scenarios.

Besides 'real' physical climate data, it is important to consolidate and improve authoritative data collections and compilations in the socio-economic and natural resources realms, using statistical surveys, as well as other sources such as satellite imagery—the end goal being to have proper, authoritative data in place to assess and address climate change issues adequately at all levels.

In terms of population, the two key variables, of course, are size and distribution—both to estimate absolute figures and to derive per capita data. As already stated, changes in distribution and size are as important, i.e., data on mortality, fertility, age composition, urbanization and migration. In addition to historical data (trends), projections and scenarios are needed to show the potential impacts and effects of environmental and other policies.

For both analysis and policy formulation activities, scale matters: "[A]s different phenomena take place at different spatial scales, the preferred spatial scale depends on the analysis undertaken" (van Vuuren et al., 2007, p. 114). Data for large regions or groups of countries are sufficient for global assessments and scenarios such as those developed in the GEO or the SRES studies. Global models, however, hide variations between and within countries (for instance, energy intensity may vary considerably from one country to another). Thus, national data are required for international negotiations or for the implementation of environmental conventions. For local activities linked to vulnerability and adaptation to climate change, such as land-planning or sanitation, detailed and geo-referenced data are needed because of the spatial variation of determinant factors such as land cover/land use, terrain, location of infrastructures and access to water, among others.

The following section addresses some of the aspects related to the comparability of information sources as well as to the spatial disaggregation of demographic data.

Comparing population data sources

Climate change modelling or environmental assessments often face the problem of data scarcity. It is also possible that more than one data source is available. This is the case for CO_2 emissions at the global level (UNFCCC and Carbon Dioxide Information Analysis Center [CDIAC] country data, for instance, can be found on the GEO Data Portal) or for population data when international data sources are compared to regional data. In this view, the European Spatial Planning Observation Network (ESPON) 2013 Database project[4] is currently conducting a compatibility study in order to evaluate the compatibility among data from the United Nations community (UN Statistical Division, UNEP) and those from the European Union (Eurostat, ESPON).

Preliminary results indicate that some countries show large discrepancies among data sources, as seen in the example of Spain where differences increase through the time-period 2000-2006 (see Figure 14.3).

In general, observed differences are higher when indicators are further disaggregated: In the example provided for data on age-classes in Belgium in 2005 (Figure 14.4), a maximum difference of 3.4 per cent is reached by the age-class 85+ against only 0.1 per cent for the total population (i.e., the sum of all age-classes). In some cases, the discrepancies can be easily explained by differences in the definition of territorial units (e.g., the inclusion of overseas territories in the definition of France), but this is sometimes less clear for other cases.

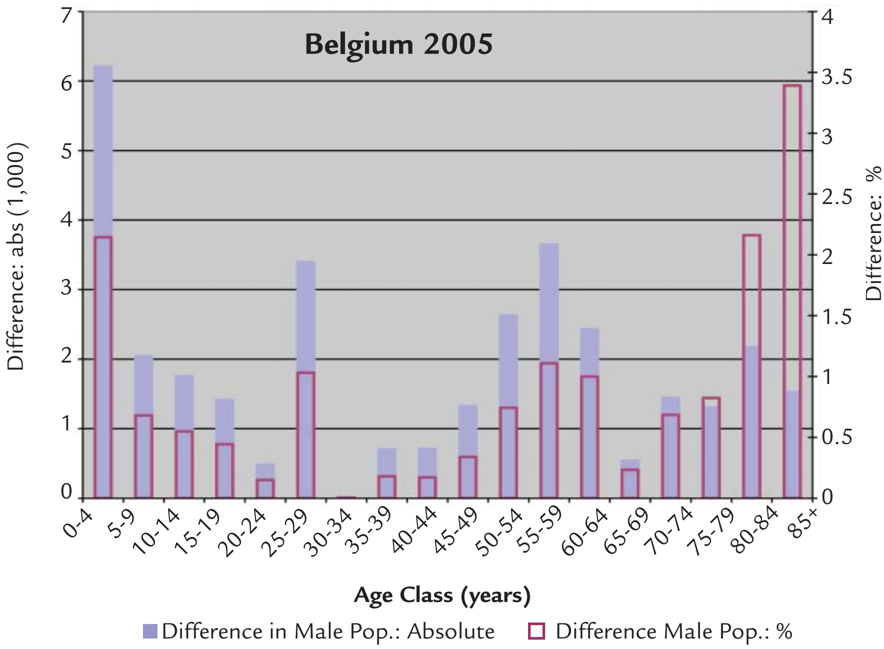
The same observations can be made for demographic projections. In the case of total population projections to 2050 for Europe, the main United Nations variants from *World Population Prospects: The 2006 Revision* (United Nations, 2007) and the models from the ESPON project 1.1.4, "The Spatial Effects of Demographic Trends and Migration" (Johansson and Rauhut, 2002), depict a wide range of scenarios (see Figure 14.5).

All scenarios are modelled using basic demographic variables such as fertility and mortality rates and migration. The inclusion (or exclusion) of these variables, along with assumptions about their evolution, explain the differences between the scenarios.[5]

Downscaling Population Data and Scenarios

Once data sources are identified and clearly understood in terms of what they measure, there may be a need to refine the available (generally measured) data by means of estimation models, in order to achieve higher spatial resolution. This process, known as spatial disaggregation, has been conceptualized and applied

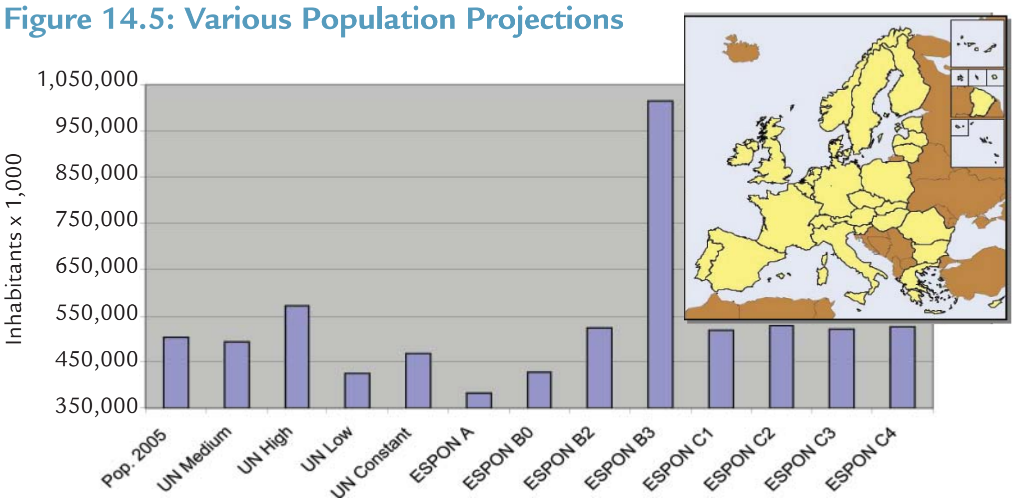
Figure 14.4: Age-class Data Discrepancies between European and United Nations Data, Belgium, 2005



in different fields including biodiversity mapping (estimation of species distribution), climate modelling and poverty and population mapping. A wide range of statistical, physical and deterministic models (or a combination of these) has been developed. The next sections focus on demographic data disaggregation models.

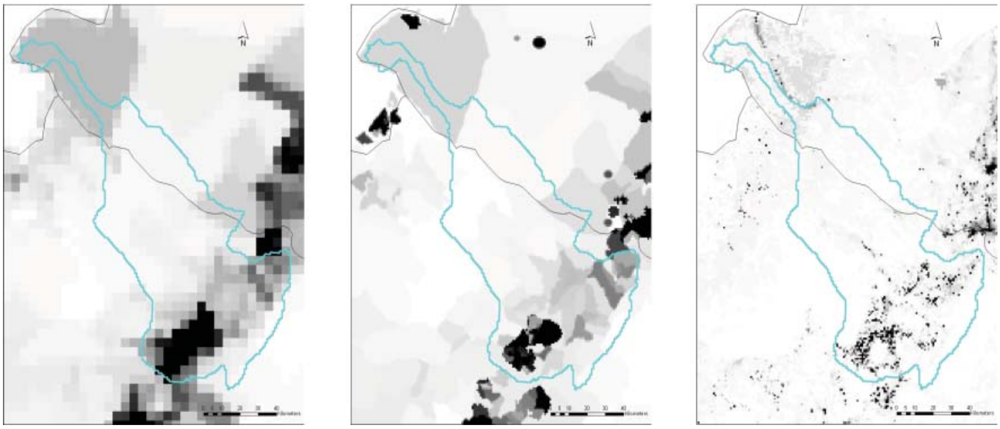
Downscaling demographic data: Population data are generally available by politico-administrative areal units (countries or sub-national units). The most complete data come from censuses. Administrative registers (population, electoral

Figure 14.5: Various Population Projections



Note: Scenarii for EU27 + CH & NO (scenarii variables: fertility, mortality, migration)

Figure 14.6: Population Exposure to a Flood, from GPW, GRUMP and LandScan Calculations



Example of population figures extracted from three data sources for a single flood event (in light blue)

lists, vehicle registrations, tax records) can provide reliable data in some countries. These data can also be complemented by surveys, which cover only a sample of the phenomenon to be observed.

The politico-administrative type of spatial units is relevant for decision-making purposes since they represent the spatial extents of political power. However, they are not well suited to environmental studies because ecological phenomena have different boundaries, if they have boundaries at all (e.g., temperature, altitude).

Since integrated models and assessments imply the combination of various dimensions of the environment, a common spatial reference is needed, the simplest one being a regular grid of square cells (a raster grid). To illustrate how data by areal units can be transformed into gridded data, four examples are briefly described in Figure 14.6.

The Gridded Population of the World (GPW v3)[6] is a global population data set at the resolution of 2.5 arc-minutes (5 km at the equator) for every five-year interval from 1990 to 2015. Data on more than 400,000 politico-administrative units (with figures from the two most recent censuses circa 1990 and 2000) have been extrapolated to the selected years and rasterized using a simple assumption of uniform distribution of population. The main effort has been in the acquisition of the most detailed source data possible. An extension of this product is the model developed by the Global Rural-Urban Mapping Project (GRUMP), which makes use of ancillary data such as satellite imagery for further distributing population between urban and rural areas at a spatial resolution of 30 arc-seconds (1 km at the equator).

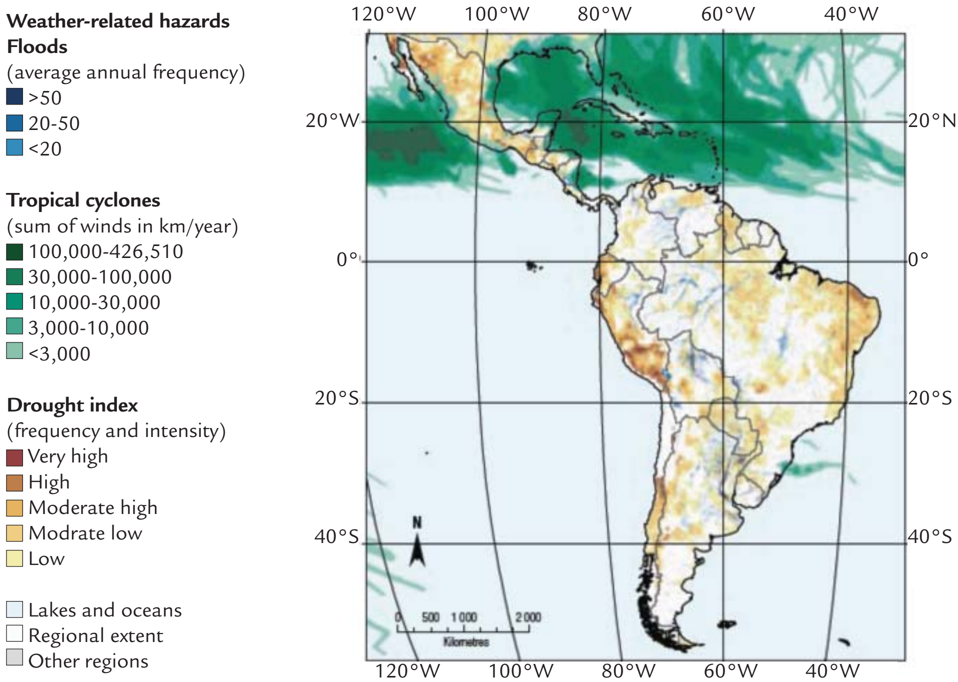
Another data set, LandScan,[7] provides a global raster grid at a 30 arc-second resolution. The assumptions for the distribution of population aim at representing the so-called ambient population, which integrates movements and travel. Night-time lights imagery, data on elevation, land cover and transportation networks are used to estimate population in each cell of the grid. The objective of LandScan is not to count people at their place of residence, but rather to provide an estimate of their "likely ambient locations integrated over a 24-hour period for typical days, weeks, and seasons".[8] The concept of ambient population differs from the residential approach of GPW. Only the most recent versions of LandScan (2006 and 2007) are available because the methodology has changed since the original 1998 modelling.

A third type of model developed at UNEP[9] also distributes population in a non-uniform way, on the basis of an accessibility index calculated by means of data on transportation and settlements. The model assumes that population tends to locate in the most accessible areas.

Starting from more or less the same demographic data by sub-national units, these models result in different pictures of population distribution. Although each model has its rationale and validity, the use of one or another has different implications. In Figure 14.6, for example, a flood event is drawn based on GPW, GRUMP and LandScan data. The calculations of the population affected by this event show contrasting figures, depending on the data source considered.

In any case, the assumptions behind the models should be known and documented. General evaluation criteria for selecting a downscaling model can nevertheless be proposed: "(1) consistency with existing local data (for the base year); (2) consistency with the original source (the scenario data on the much coarser scale); (3) transparency; and (4) plausibility of the outcome" (van Vuuren et al., 2007, p. 115). These criteria are partially met by the GPW/GRUMP and LandScan data sets. Local data have been used in the GPW/GRUMP grids since they are derived from almost 400,000 base administrative units, against 70,000 for LandScan 2000 (although several thousand units have been added in subsequent versions of LandScan). The consistency with original data is met by both data sources, since the GPW/GRUMP and LandScan methods simply distribute population within each original spatial unit. Furthermore, GPW provides additional extrapolated population grids that are explicitly adjusted to United Nations' national scenarios until 2015. The transparency is very high for the GPW/GRUMP products: Methods and data sources have been documented and published. For LandScan, a basic documentation is available, but demographic data sources are not clearly described, and the details of the method were not published. LandScan, however, has evolved in such a way that comparisons between the various updates are impossible. Finally, the plausibility of the modelled population values depends on the objective of the users. The GPW grid is based on the assumption of a uniform distribution of population within each spatial unit, which is in fact very unrealistic. But this is counterbalanced by the effort put into collecting the most possibly detailed base demographic data. GRUMP, while improving the GPW spatial resolution by a factor of five, is also introducing a more precise distribution of population between urban and rural areas. Both GRUMP and GPW provide an indication of the residential population. LandScan, on the other hand, assesses a very different concept of ambient population, i.e., the potential presence of population through

Figure 14.7: Compilation of Hazard Data, South and Central America



Source: ISDR, 2009.

time at a given place for various reasons (residence, travel, work, leisure, etc.). This idea might be relevant, for instance, for risk management purposes.

Downscaling scenarios: Similar to downscaling actual data, demographic projections and scenarios have been spatially disaggregated in recent global assessments. For instance, various models for downscaling the IPCC's Special Report on Emissions Scenarios (SRES) scenarios to the grid level (0.5° x 0.5°) have been developed (Gaffin et al., 2004; Grübler et al., 2007; van Vuuren et al., 2007). These models downscaled drivers of climate change: emissions, population and GDP. In the most recent of the examples cited (van Vuuren et al., 2007), 17 world regions of the SRES scenarios were downscaled to the national and grid-size levels (0.5° resolution, i.e., 55 km at the equator). In order to achieve the grid estimation of population, national growth rates for each of the SRES scenarios have been linearly applied to each grid cell of the GPW 2000 data which is used as the base grid. The gridded GDPs were obtained by multiplying the national GDP per capita by the population grids. GHG emissions were only disaggregated at the national level by means of the I = PAT model.

For further sub-regional or national studies, finer downscaling might be needed in order to reach decision-making relevance at these scales. In particular, emissions should be disaggregated at the grid level, and more data on land-cover/land-use change incorporated. This is, for instance, the aim of the recently launched

European Union's Seventh Framework Progamme's (EU/FP7) Envirogrids[10] research project, which will evaluate the impacts of climate change on the quality and uses of water in the Black Sea Basin (covering 2,000,000 km^2, 24 countries, 160,000,000 inhabitants.). Climatic and demographic scenarios will be downscaled to 25 km and 1 km resolutions, respectively. Land-cover data already available at medium resolutions (250 m to 1k m) will be projected up to 2030. The main challenge in this modelling process is to keep the models as independent as possible (e.g., not to use population scenarios for forecasting land-cover changes) in order to allow comparisons between the resulting figures.

Data Needs for Long-term Analysis of Impacts, Vulnerability and Adaptation

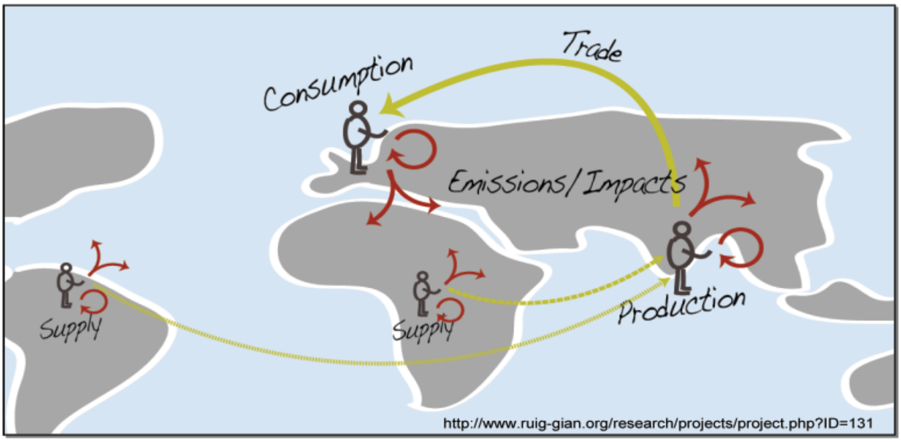
Long-term early warning

Previous sections have introduced the complexity of designing and acquiring appropriate data from the thematic and spatial points of view. The time dimension is also essential when considering the inherent uncertainties of scenarios and projections, but also important for establishing mitigation and adaptation policies. Many people seem to agree that the hard distinction between short-term disaster response and recovery and longer-term planning is not necessarily beneficial for policymaking.

Most people think of early warning in terms of immediate and short-term concerns such as major weather events (hurricanes, cyclones, tornadoes and the like), climatic variation (El Niño events or droughts caused by lack of rainfall) or geo-physical events such as earthquakes and tidal waves. These immediate and often unpredictable events require specific measuring, information and advisory systems, as implemented or coordinated by specific national and international organizations. These activities are essential for efficient response and recovery actions, but the focus of organizations such as UNEP is also on identifying issues which take much longer to develop and might better be identified as 'emerging environmental threats'. These may take the form of environmental degradation that increases the vulnerability of ecosystems (including humans, often in combination with socio-economic stresses); cumulative environmental threats where the accumulation of pollutants collectively increases the vulnerability of ecosystems; environmental threats that have not been perceived as such in the past, but that new evidence indicates might be deleterious to ecosystems; or more speculative, long-term issues where scientific evidence may be inadequate at present but discussions and assessments have identified as a possible environmental problem. Depending on the relative socio-economic vulnerability of a given community, these environmental threats can (drastically) alter ecosystem functioning and have a major impact on human security and the biodiversity of the planet. The recognition that environment is a key ingredient of development has made the ability to provide early warning on longer-term and cumulative environmental threats much more important.

Figure 14.8: Tracking Consumption, Production and Health Impacts

Pollutant emissions and impacts do not occur only at place of consumption



Source: Tracking Environmental Impacts of Consumption (TREI-C), a research project @ GRID-Europe.

Global assessment of environmental risks

Such long-term linkages between environment and development is central to the recently published Global Assessment Report (GAR) (ISDR 2009), a global study of intensive and extensive disaster risk in the context of development and climate change. It is a very good example of an integrated approach to a subject (disaster risk) that cannot be analysed in one unique dimension. This report links the observed or potential losses to the exposure and vulnerability of population and assets towards natural hazards. The conceptual framework of global risk modelling is a simple equation proposed by the United Nations Disaster Relief Organization (UNDRO, 1979):

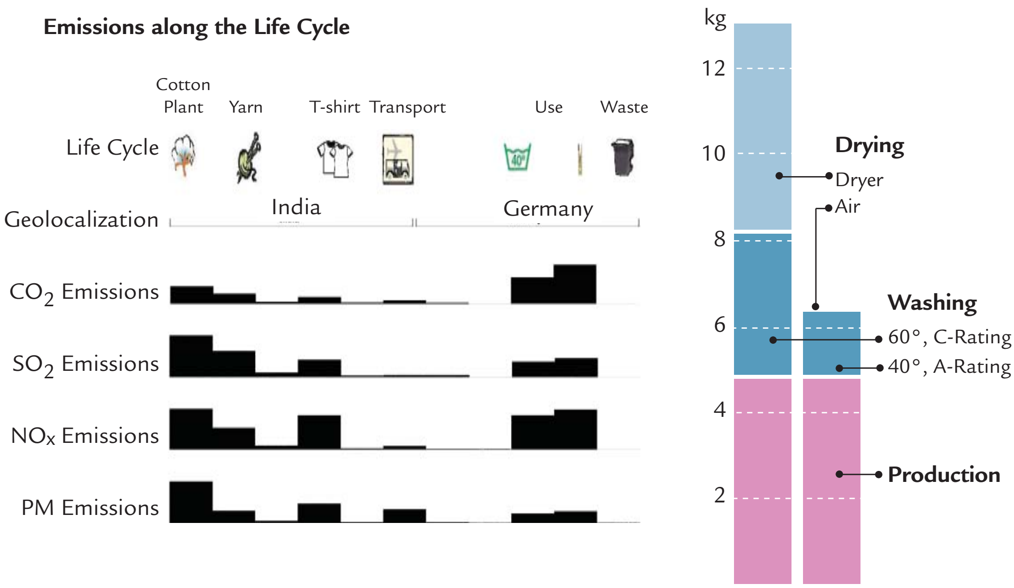
Risk (losses) = hazard x exposition x vulnerability

The most possibly detailed data on losses (human and economic, from the EM-DAT[11] and DesInventar[12] databases) and hazards (including cyclones, droughts, floods, earthquakes, tsunamis, landslides) have been compiled (see Figure 14.7).

The hazard maps have been overlaid on the gridded population (LandScan) and GDP data in order to calculate human and economic exposures to each of these risks. Finally, a statistical analysis of vulnerability indicators (mainly available at the national level) enabled the identification of the main risk factors, such as poverty, poor governance, urban population growth, isolation of rural areas and ecosystem decline. All these factors need to be addressed in the long term.

One other striking conclusion of the report is that risk and exposure are highly concentrated and increasing. Despite the successes attained in vulnerability reduction (through development), risk is still rising because of the growing exposure of people and their assets.

Figure 14.9: Emissions during the Life-cycle of a T-shirt



Effects of climate change were also related to the observed increase in intensity of hydro-meteorological hazards such as cyclones. But the evaluation of the impacts of climate change on hazards is only at an early stage and requires further investigation. This is particularly important because more than two thirds of the mortality and economic losses from reported disasters (1975-2008) are associated with hydro-meteorological hazards. Although a large amount of risk, hazard and vulnerability data compiled for the GAR report is already made freely available on the internet,[13] it is expected that more data will be collected on the various dimensions of risk since "there is a growing international commitment to addressing disaster risk, poverty and climate change" (ISDR, 2009, p. 14).

Closing the circle: linking consumers, producers and the impacted population

Risk analysis also shows that drivers of climate change in one place (e.g., emissions in industrialized countries) may have impacts in other places (e.g., in poor and vulnerable countries). In addition, situations today can lead to future vulnerabilities. Environmental assessments have to take into account remote distances and futures, which, in fact, is in line with the principles of sustainable development. Examples of such approaches can be found in the novel ways environmental and economic accounting are being carried out. It is now recognized that classical national (e.g., Kyoto protocol emissions accounts) or residence-based accounting (e.g., GDP) must be complemented by other allocation schemes in order to properly evaluate the impacts of the consumption of goods and services throughout the world. Life-cycle analyses—as well as multi-directional/multi-sectoral trade flow data (such as the GTAP databases[14])—permit the reallocation of emissions among consumers and producers. Such models have so far mainly been applied to regional analyses of global pollutants such as CO_2. They have shown large discrepancies in the carbon intensities of production between producing and consuming regions.

The recent TREI-C study[15] has included emissions of additional pollutants such as fine particles or heavy metals and assessed their health impacts in terms of disability-adjusted life years (DALYs). Such a model thus integrates life-cycle analysis, macroeconomic data on trade and production, pollutant transfer models (through air and water) and epidemiological studies about the effects of pollutants on health.

The integration of such diverse models is required for tracking the complete chain of causality from consumption to final impacts through time, space and actors (see Figure 14.8).

The life-cycle analysis provides crucial information about where and when most pollutant emissions occur during the lifetime of any given item. In the case of a T-shirt, which was carefully examined in the TREI-C study, it was demonstrated that the use phase can double CO_2 emissions due to the frequent use of washing machines and electric dryers (see Figure 14.9).

For such easy-to-track examples, mitigation measures appear immediately: Consumers have to wash less and/or producers must design clothes that do not smell! Unfortunately, other types of goods such as electronic appliances are made of a complex mix of components produced in many parts of the world. The life-cycle analysis of such products would require more data which may be available in the future, as the interest in such new types of accounting will grow in the context of international environmental negotiations.

Conclusions

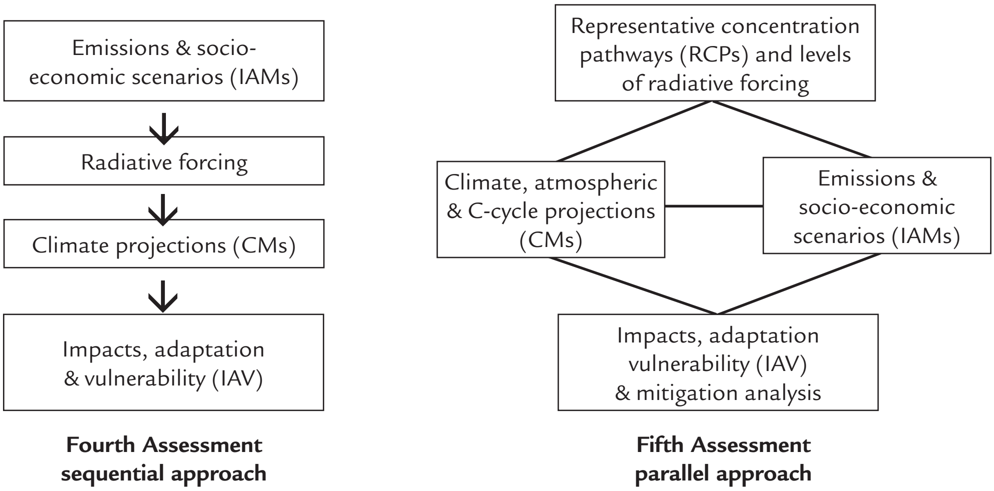
The following general conclusions can be drawn from the examples of data analysis and applications that have been presented in this chapter, as well as from the need for more attention to population issues related to the environment and climate change:

1. The role of population data for climate change analysis can be strengthened and linked to the reorganization within the IPCC and the lack of coverage of population issues in the current debate.

Population dynamics are at the centre of the climate change issue, yet they receive little attention. The general debate focuses more on the economic and technological aspects. However, there is undoubtedly a strong interest by the international and scientific communities in better integrating population in the analysis and properly assessing the population-related causes and impacts of climate change. More and better population data in terms of contents, scale, quality and time coverage are needed in order to undertake more relevant and rigorous scientific assessments that can have a significant influence on the political and societal debates.

With the reorganization of the analysis and assessment activities for the IPCC Fifth Assessment, population and socio-economic scenarios are no longer at the

Figure 14.10: Approaches for the Development of IPCC Global Scenarios



Source: Modified from Moss et al. 2008.

base of all subsequent sequential analyses (see Figure 14.10), as was the case in the IPCC Fourth Assessment. With the newly adopted parallel approach (Moss et al., 2008), population and socio-economic scenarios are now directly linked to the three other components, and therefore the need for improved population data is even greater.

2. There is a need for broader consultation and discussion around the needs for data collection and analysis.

Generally speaking, there is a clear need for better identification and expression of data needs for addressing climate change and population dynamics. Due to the complexity and interlinkages of these issues, conceptual and formal models must be further developed, taking into account the availability of data.

The methods for data creation and estimation must be made more explicit, and they must be made more understandable to a wider audience. In particular, the distinction between observed and modelled data must be clarified, in order to address issues of uncertainties attached to some data, such as projections. The IPCC Fourth Assessment Report (AR4) provides a good example of how to present synthesized methodologies and evaluation of uncertainties.

In order to support such global assessments with relevant socio-economic data (including data on adaptation and mitigation), improved international cooperation is necessary. Data is costly to acquire and maintain; priorities must be set; redundancy and overlap in the collection and dissemination of data must be avoided where possible.

Nevertheless, variety and discrepancies in data sources, in particular between international and local scales, will always be observed. Acknowledging and explaining these differences is necessary, i.e., identifying the reasons for such variability, whether this is linked to definitions of the observation or measurement units or to measurement techniques. Coordination will not necessarily or always lead to the consensus and efficiency, for example, of appropriate and unique data sources in each thematic domain (demography, vulnerability, adaptation, etc.). Similar data may seem redundant but still have their own rationales for existence. For instance, data sets on transportation networks are sometimes acquired and analysed several times by many different actors in the same territory (public administrations, private companies, specific projects, etc.) due to specific information needs, different levels of application or various copyright issues.

In this respect, participation in evaluation processes and trust-building between stakeholders in climate-change assessment activities is important in order to validate the data provided.

3. Quantitative data analysis needs to be integrated with evaluations of governance and other qualitative assessments.

When attempting to integrate heterogeneous actors and ways of measuring reality, it is necessary to compare and evaluate numeric data and formal models with other types of more qualitative knowledge, including expert opinion, common sense and indigenous information. There are conceptual and practical reasons to consider subjective evaluations (e.g., governance indicators, perception of risk by local actors). Many agencies have relevant data to bring to the debate, and it can certainly be more efficient to integrate them early in the assessment process, rather than to be confronted with opposition and rejection once the figures are published.

4. There are excellent opportunities for strengthening the role of the United Nations in moving the population-climate agenda forward.

In the broader participatory and catalysing aspects of data management, the United Nations can play an instrumental role by fostering and coordinating data collections at global, regional and national levels, as well as by improving the coherence, quality and accessibility of population data for a greater knowledge of the complex problems at stake. All this, with the ultimate goals of improving the science base for sound decision-making and taking sustainable actions.

Notes

1 According to IPCC (2007), in 2000, UNFCCC Annex I countries (industrialized countries) had 0.683 of kg $C0_2$-equivalent emissions per US$ of GDP_{PPP} against 1.055 for developing countries.

2 See: UNEP, 2007.

3 See: UNEP, n.d., Geodatas.

4 See website: www.espon.eu/, last accessed 2 October 2009.

5 The ESPON scenarios A (no immigration) and B3 (with high immigration for a constant age-dependency ratio) are unrealistic but illustrate the problems of immigration and financing retirement systems.

6 See: SEDAC/CIESIN, n.d.

7 See: Landscan, n.d.

8 See the documentation on the LandScan website: www.ornl.gov/sci/landscan/, last accessed 7 October 2009.

9 See website: http://na.unep.net/globalpop/africa/, last accessed 8 October 2009.

10 See website: www.envirogrids.net/, last accessed 2 October 2009.

11 See Emergency Events Database website: www.emdat.be/, last accessed 3 October 2009.

12 See website of: Corporacíon OSSO, Valle, Colombia: www.desinventar.org/, last accessed 1 October 2009.

13 See: UNEP, n.d., Preview.

14 See: Purdue University, n.d.

15 See: International Academies Network, n.d.

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Population matters for climate change.

This book broadens and deepens understanding of a wide range of population-climate change linkages. Incorporating population dynamics into research, policymaking and advocacy around climate change is critical for understanding the trajectory of global greenhouse gas emissions, for developing and implementing adaptation plans and thus for global and national efforts to curtail this threat.

Substantial resources are being dedicated to research and policy efforts to mitigate climate change and support adaptation to the current and future impacts of greenhouse gas emissions. Yet the lack of consideration of population dynamics hampers the development of stronger, more effective solutions to the challenges climate change poses. The papers in this volume provide a substantive and methodological guide to the current state of knowledge on issues such as population growth and size and emissions; population vulnerability and adaptation linked to health, gender disparities and children; migration and urbanization; and the data and analytical needs for the next stages of policy-relevant research.

In 2010 and beyond, as the world develops and implements new climate-change strategies, and as the need for action heightens every day, this volume will help to fill one of the most significant gaps in the global response to date.

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