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Equity, Environmental Justice, and Urban Climate Change

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Equity, Environmental Justice, and Urban Climate Change

Cities are characterized by a great diversity of socioeconomic groups living in close proximity. Diversity is often accompanied by stratification based on class, caste, gender, profession, race, ethnicity, age, and ability. This gives rise to social categories that, in turn, affect the ability of individuals and various groups to endure climate stresses and minimize climate risks.

Differences between strata often lead to discrimination based on group membership. Poorer people and ethnic and racial minorities tend to live in more hazard-prone, vulnerable, and crowded parts of cities. These circumstances increase their susceptibility to the impacts of climate change and reduce their capacity to adapt to and withstand extreme events.

Major Findings

- Differential vulnerability of urban residents to climate change is driven by four factors: (1) differing levels of physical exposure determined by the location of residential/occupational areas; (2) urban development processes that lead to risks, such as failure to provide access to critical infrastructure and services; (3) social characteristics that influence resources for adaptation; and (4) institutional and governance weaknesses such as ineffective planning and absence of community engagement.

- For New York, London, Dar es Salaam, and Durban, risk levels increase dramatically for all key risks in the long-term, especially for the 4°C warming. But, at least for now, in the near-term, and mostly for the long-term with a 2°C temperature rise, a high level of adaptation can keep risks down. However, under a 4°C temperature rise, adaptation measures are likely to be ineffective not only in Dar es Salaam but also in cities with currently high levels of adaptation, such as New York and London.

- Climate change amplifies vulnerability and hampers adaptive capacity, especially for the poor, women, the elderly, children, and ethnic minorities. These people often lack power and access to resources, adequate urban services, and functioning infrastructure. Gender inequality is particularly pervasive, cutting across a number of documented inequities such as income, disability, and literacy, which in turn contribute to differential consequences of climate changes.

- Frequently occurring climate events, such as droughts in many drought-prone areas, can, over time, undermine everyone's resource base and adaptive capacity, including better-off urban residents. As climate events become more frequent and intense, this can increase the scale and depth of urban poverty overall.

- Mobilizing resources to increase equity and environmental justice under changing climatic conditions requires the participation of impacted communities and the involvement of civil society; nontraditional sources of finance, including partnerships with the private sector; and adherence to principles of transparency in spending, monitoring, and evaluation.

Key Messages

Urban climate policies should include equity and environmental justice as primary long-term goals. Equity fosters human well-being, social capital, and sustainable social and economic urban development, all of which increase a city's capacity to respond to climate change. Access to land situated in nonvulnerable locations, security of tenure, and access to basic services and risk-reducing infrastructure are particularly important.

Cities need to promote and share a science-informed policy-making process that integrates multiple stakeholder interests to avoid inflexible, top-down solutions. This can be accomplished by participatory processes that incorporate community members' views about resilience objectives and feasibility.

Over time, climate change policies and programs need to be evaluated and adjusted to ensure that resilience and equity goals are reached. Periodic monitoring and evaluation using fair indicators and progress measurements, budgetary transparency, and equitable resource allocation schemes are essential to ensure that funds reach target groups and result in equitable resilience outcomes.

6.1 Introduction

This chapter focuses on equity and environmental justice aspects of climate change in and across cities. Within cities, climate change equity and environmental justice aspects are important due to distinctive urban characteristics related to socioeconomic and ethnic diversity as well as to high density (UN-Habitat, 2010). Diversity is often accompanied by stratification – a permanent social process – based on, for example, class, caste, gender, profession, race, ethnicity, age, and ability. This gives rise to social categories within urban populations that affect the capacities of individuals and groups to endure climate stresses and to adapt to or minimize climate risks (Dodman, 2009; Marino and Ribot, 2012). Differences between strata potentially lead to discrimination and unfair treatment of individuals due to group membership, thus raising equity issues (Dovidio et al., 2010). For example, poorer people and ethnic minorities tend to live in more vulnerable locations and crowded parts of cities, increasing their susceptibility to climate change impacts and lowering their adaptive capacities to withstand risks.

Between cities, climate change equity and environmental justice issues arise for cities that have traditionally emitted greenhouse gases (GHGs) at low rates per capita but experience higher than average climate change impacts, such as many cities in low-income countries. For example, the 23 mega-disasters (those with more than 10,000 fatalities, excluding epidemics) that occurred between January 1975 and October 2008 mainly affected low-income countries, causing 78% of mortality from only 0.26% of the total number of events (UNISDR, 2009). Cities that are affected by higher-than-average climate change impacts show particularly high population growth rates – especially those in low-income countries of Asia and Africa (Wheeler, 2011), where nearly 90% of the increase in urban population between now and 2050 is expected to take place (UNDESA, 2014).

These trends put ever-increasing numbers of people at risk from climate change and will potentially amplify equity and environmental justice issues because the growth of cities in Asia and Africa is likely to correspond with an increase in slum populations. Currently, 62% of the population in Africa and about 30% in Asia live in slums (UN-Habitat, 2010). Although, the proliferation of densely populated informal settlements – often fueled by rural–urban migration – is also a sign of growth and anticipated development and therefore of the "success" of a city, rapid urban growth poses a major challenge for city managers. It is often associated with unplanned and unregulated settlements in risk-prone areas (UN-Habitat, 2013a; Revi et al., 2014).

A changing climate will also act to further amplify equity issues in cities of high-income countries, as shown by extreme heat waves in Central Europe in 2003, causing between 22,000 and 35,000 deaths of mainly elderly people (Schär and Jendritzky, 2004); in Chicago in 1992, claiming 739 excess deaths in mainly lower-income neighborhoods (Klinenberg, 2003); and in Melbourne in 2009, with 374 heat-related deaths (Victorian Government Department of Human Services, 2009).

6.1.1 Objectives

In this chapter, we assess how climate change risk, impacts, adaptation, and mitigation actions in cities relate to equity. For each of these dimensions, the chapter provides a synthesis of the various factors that affect equity issues under current climate conditions and discusses how further climate change might potentially increase or decrease equity in the future. Equity issues affecting urban centers in low-, middle-, and high-income countries are considered. We stress the particularities of urban contexts – including socioeconomic characteristics, location, and potential for policy interventions – and the wide spectrum of capacity to respond.

Section 6.1 provides an introduction and an overview of the chapter. It provides explanations of key terminology and introduces the relation of equity to climate change in cities. Section 6.2 discusses the nexus of climate change impacts and adaptation, and equity, with a focus on common impacts and risk factors as well as on hazard-specific risk factors such as high temperatures, heavy precipitation, and sea level rise. Section 6.3 highlights equity concerns in regard to mitigation, including aspects of transportation, land use, energy, and waste management. In Section 6.4, we draw attention to lessons from the implementation of climate change policies and practices in cities. Section 6.5 evaluates a number of frameworks for assessing equity and presents an Urban Equity Impact Assessments (EquIA-urban) Guide for policy-makers. Section 6.6 summarizes knowledge and research gaps. The chapter concludes with policy recommendations for city leaders and national-level decision-makers.

6.1.2 Definitions, Principles, and Domains

Promoting equity is an implicit (and sometimes explicit) goal of many local and regional climate initiatives (McDermott and Schreckenberg, 2009). However, it is often unclear which aspects of equity (see Box 6.1) are being referred to: equity in the distribution of costs and benefits or in privileges and burdens; between individuals such as women and men or between households within communities; between urban districts, local groups, and national stakeholders or generations of urban residents. These aspects refer to one dimension of equity concerns – outcome-based aspects – whereas, three scholarly dimensions are distinguished:

1. Outcome-based, distributive, or consequential equity;
2. Process-oriented or procedural equity (Metz, 2000; McDermott et al., 2011);
3. Contextual equity (McDermott and Schreckenberg, 2009).

Outcome-based equity relates to the consequences of a policy, action, or developmental trend, which is acknowledged to be important for both low-and high- income countries. Procedural equity refers to impartiality and fairness in the process of delivering and administering justice (Shukla, 1999). This is more often discussed in relation to urban climate initiatives in low-income

Box 6.1 Definitions of Terms: Fairness, Justice, Equity, and Equality

The terms "fairness," "justice," and "equity" are often used interchangeably in development discussions (Metz, 2000; Kallbekken et al., 2014). Some distinctions has been suggested by Rawls (1971), who saw justice and fairness as being distributive concepts and equity as the normative criterion for judging this distribution (Fahmi et al., 2014; Dankelman et al., 2008; WEDO and UNFPA, 2009). Soltau (2009) uses the term "fairness" for the more general concept of distributional norms and the term "equity" for a particular subset of these norms (Kallbekken et al., 2014). However, what exactly qualifies as "fair" or "just" depends on personal or cultural judgment (Rawls, 1971, 1993; Barry, 1995; Linnerooth-Bayer, 2009; McDermott et al., 2011). It is therefore important to consider who decides what is equitable, fair, and just.

Fairness practices are thought to enhance the quality of social life, and a good society has been defined as one in which norms of fairness play a significant role in guiding human behavior and government policies (Kallbekken et al., 2014; Moser, 2011). The fact that some fairness principles are frequently invoked and rarely disputed indicates that they have some "normative clout" (Kallbekken et al., 2014; Tovar-Restrepo, 2010; Schildberg, 2014). This means that some constraints on the actions of self-interest are generally agreed to be favorable for all in the long run.

Justice can refer to either social or environmental justice. The social justice movement seeks to establish fair distributions of wealth, opportunity, and privileges by means of fair treatment, proportional distribution, and the meaningful involvement of all people in social decision-making. The goals of the environmental justice movement are healthy environments and protection from environmental hazards for all people, regardless of race, nationality, origin, or income (EPA, 2011). Environmental justice interacts with environmental risk, exposure, impacts, sensitivity, and adaptive capacity. In that respect, social justice and environmental justice are inextricably linked. However, growing environmental concerns have arguably detracted from efforts to increase social justice in the political arena (Agyeman et al., 2003; Khosla and Masaud, 2010).

Distinguishing equity and equality is more straight-forward: *equality* refers to an equal treatment of equal cases or a "state or quality of correspondence in quantity, degree, value, rank, or ability" (Random House, 2014), for example with respect to status, rights, or opportunities. In urban areas, crucial components of equality include the right to adequate housing and security of tenure; and affordability, accessibility, location, culture, and availability of services, infrastructure, and facilities. *Equity* refers to the impartial treatment of cases that may differ in important respects (Kallbekken et al., 2014) (see Box 6.1. Table 1).

To simplify the discussion in this chapter, we mostly use the term "equity," with the aim of exploring the issues of fairness, justice, equity, and equality arising from climate change in cities.

Box 6.1 Table 1 *Broadly accepted fairness principles. Source: Kallbekken et al., 2014*

Fairness principle	Summary definition	Explanation
Equality	Equal treatment of equal cases	Relevant differences not important, e.g., all urban residents shall have equal right of security of tenure
	Proportional treatment of similar cases	Relevant differences important, e.g., different, but fair and equitable payment for jobs requiring different skills
Equity	Exceptional treatment of dissimilar cases	Relevant differences very large and/or cases dissimilar, e.g., special treatment for entities with no moral responsibility for damage and/or very low problem-solving capacity

countries (Bulkeley et al., 2013). Contextual equity links the first two dimensions by taking into account pre-existing political, economic, and social conditions.

In order to operationalize equity, McDermott et al. (2011) relate these dimensions to three parameters: target, goal, and process (see Figure 6.1). Operationalization is further based on principles and indicators, of which a large number have been proposed (Metz, 2000; Klinsky and Dowlatabadi, 2009; Cazorla and Toman, 2000) (see Table 6.1).

Support for equity principles and operational indicators differ between low-income and high-income countries (Shukla, 1999; Kallbekken et al., 2014) and potentially on subnational and local levels. Among delegates to the climate change negotiations of the United Nations Framework Convention on Climate Change (UNFCCC) the "polluter pays" principle had most support, at least in a short-term perspective (i.e., ≤20 years). This was followed by "the exemption of the poorest" and "ability to pay." An "egalitarian" principle (equal mitigation pledges) was not supported by many delegates and even more objected to the "sovereignty" principle (i.e., the full right and power of a state to govern itself and decide on its mitigation pledges) (Kallbekken et al., 2014; Lange et al., 2010). Cazorla and Toman (2000) conclude that efforts to find a "magic" solution to equity disputes are likely to be in vain, and the question of which international climate policies will be equitable over the long term will require a great deal of additional time and effort to resolve. However,

Table 6.1 *Commonly applied equity domains in international climate change mitigation efforts Kallbekken et al., 2014*

	Object to be allocated (distributed) on basis of …	
Focus on	**Costs (obligations)**	**Benefits (rights)**
Causes of the problem	Moral responsibility ("guilt" in having caused the problem)	Previous contributions (to providing the benefits under consideration) (not frequently claimed, at least in UNFCCC negotiations)
Consequences of the solution	Capabilities (capacity to contribute to problem solving)	Need for (or right to) the outcome to be achieved, i.e., goods or services of a policy

UNFCCC: United Nations Framework Convention on Climate Change

after COP21 in Paris and its agreement, the establishment of Nationally Determined Contributions (NDCs) offers another approach to the problem of who should pay and which amount. Now, each nation presents its voluntary commitments to reduce the GHG emissions, which brings a sense of ownership to the countries and also makes compliance enforcement easier.

6.1.3 Equity and Climate Change

Equity, equality, and environmental justice issues first entered the debate on climate change when it was recognized that countries that historically contributed least to global warming might be impacted the most by climate change in the future (UNEP, 2014b, UNDP, 2004; Revi et al., 2014), although, due to interdependencies, will likely also increase impacts in high-income countries (Nabangchang et al., 2015). Consequently, initial discussions revolved around mitigation responsibility and pledges. However, Metz (2000) stresses that the equity discussions around climate change should not only consider mitigation, but also explicitly take account of impacts and adaptation. This is of particular importance for urban areas because it is at local and regional scales where differential impacts and adaptation needs will unfold. Discussion on justice in adaptation has recently gained momentum (Sovacool et al., 2015; Shi et al., 2016). And because the impacts of climate change and risks are reduced by adaptation and mitigation, all three dimensions play a role (see Figure 6.2).

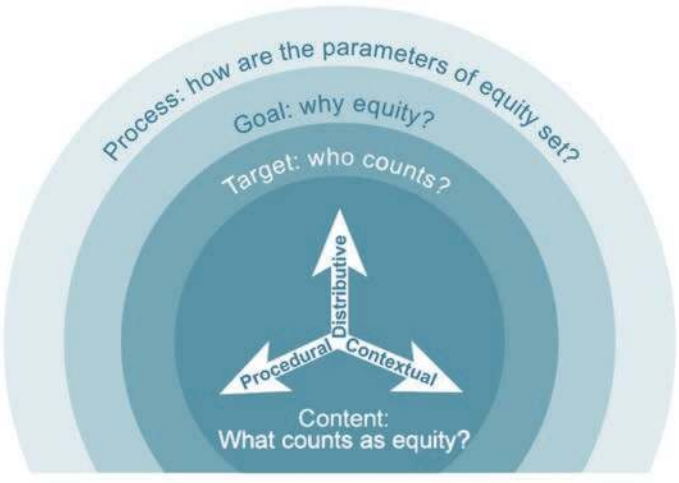


Figure 6.1 *The equity framework.*

Source: McDermott et al., 2011

Impacts of climate change differ among people and groups because of interacting socioeconomic conditions based on income; assets; and discrimination related to minority status, race or ethnicity, sex and gender, age, poor health, and impaired mobility. These characteristics influence where people live and how severely they are affected. However, it is not just the most susceptible who are impacted. Regularly occurring events can also gradually undermine the resource base of more resilient groups in society, ultimately leading to increases in the scale and depth of urban poverty (Tyler and Moench, 2012; Tompkins et al., 2013).

High exposure and sensitivity to climate impacts often coincide with low adaptive capacity (The World Bank, 2010). In this respect, it is important to recognize the current vulnerability of many cities in low- and middle-income nations and the limited capacity of their governments and inhabitants to adapt to a changing climate (Revi et al., 2014). Differential vulnerability can often be attributed to deficiencies with respect to the quality and location of infrastructure and housing, availability of social services and facilities, opportunities and access to education, and effectiveness of planning systems, as well as lack of resources and low levels of community and individual adaptive capacity (Sen, 1999; Taylor, 2013; Revi et al., 2014). Adaptive capacity is also eroded over time through repeated coping and "risk accumulation processes" (Satterthwaite et al., 2007; Rodin, 2014), with knock-on effects for chronic poverty (UNISDR, 2009).

Mitigation issues are also a concern of contemporary urban planning because an approximate 70% of the global total CO_2 emissions are from urban areas (depending on measurement protocols), principally from cities in middle- and high-income nations (Seto et al., 2014). Some cities, with encouragement from city networks such as the C40 Cities Climate Leadership Group and ICLEI—Local Governments for Sustainability, have shown farsighted leadership in setting targets (Reckien et al., 2014) and devising and implementing plans to reduce GHG emissions, but it is important to evaluate such commitments with respect to the distribution of the benefits and burdens.

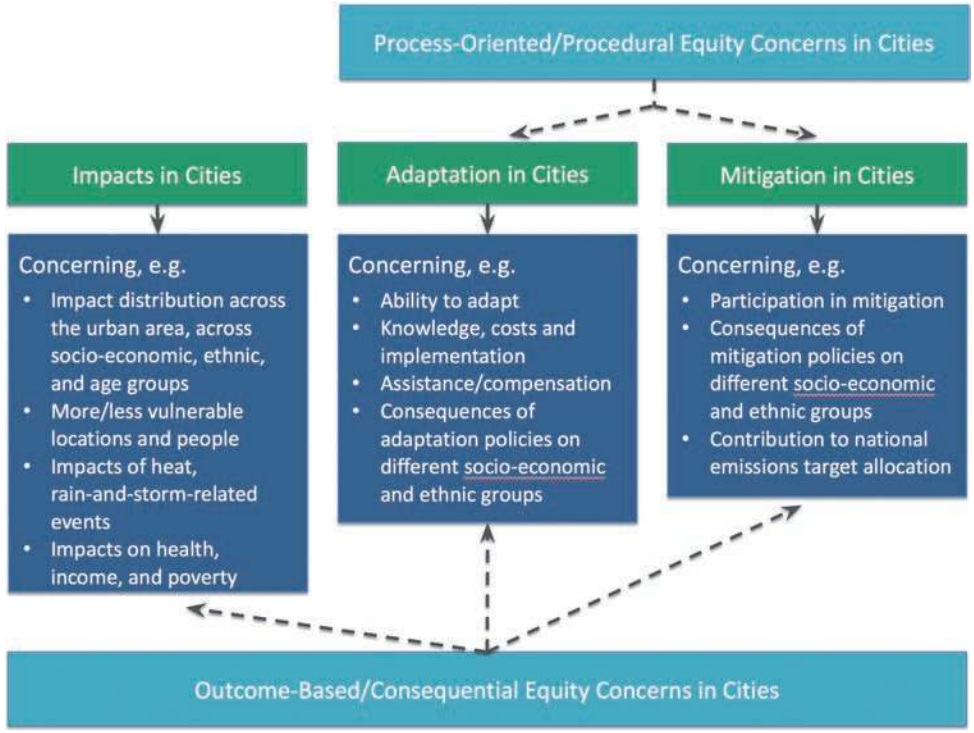


Figure 6.2 *Conceptualization of equity in climate policy.*

Source: Adapted from Metz, 2000

6.2 Equity, Urban Impacts, and Adaptation

The extent to which climate change or extreme weather events pose risks to urban residents and lead to immediate or long-lasting impacts depends on a combination of several factors (Adelekan, 2010; Fuchs, 2010). Physical exposure, as determined by the location of a community, is one factor, whereas urban development processes or so-called inherent or "constructed risk" is another (Eiser et al., 2012; McBean, 2012). Risk is also associated with the social, economic, and demographic characteristics of a population (Barrios et al., 2006), leading to vulnerability that couples with institutional, power, and governance aspects (Bulkeley et al., 2009; UN-Habitat, 2008a). Most of these factors are interrelated. They play out in low-, middle-, and high-income nations and in large, medium and small cities as a result of historical as well as contemporary urban development processes (Adelekan, 2012; Awuor et al., 2008; Fuchs, 2010).

6.2.1 Exposure, Social Context, Demographics, Governance, and Power

There is growing evidence that impacts of both gradual climate change and extreme weather events (such as tropical storms, heat waves, and excessive precipitation) disproportionately affect people with low incomes and low social status, for example in Indian and South American cities (Reckien et al., 2013; Reckien, 2014; Hardoy and Pandiella, 2009), and especially women (see Box 6.2). However, it is important to note that the most vulnerable are not the only ones impacted; regularly occurring events such as droughts and floods also undermine the resource base of better-off groups in society (Tyler and Moench, 2012; Tompkins et al., 2013). People may also be susceptible to multiple risks (e.g., infants, young children, and older age groups with impaired mobility).

Geographic and locational factors also have a major influence on climate risks. In cities in low- and many middle-income nations, such as Lagos (Adelekan, 2010), Cairo, Alexandria (Hereher, 2010), Rio de Janeiro (de Sherbinin and Hogan, 2011), Dhaka (Khan et al., 2011), and other Asian cities (Fuchs, 2010), residents with low social status and low incomes characteristically inhabit areas more exposed to climate risks, such as low-elevation coastal zones and flood plains. Housing located in high-risk urban areas is often constructed illegally and without adhering to building codes. These areas typically have high population densities and poor-quality buildings (UNISDR, 2009), leaving residents, predominantly from the lower social classes, exposed to climate risks and potentially severe impacts.

Figure 6.3 shows an indicator for (1) Equity and Social Inclusion, as measured by UN-Habitat (2013b) as part of its City Prosperity Index (CPI). It subsumes the subdimensions (and indicators) of economic equity (urban Gini coefficient and poverty rate), social inclusion (slum households, youth unemployment), and gender inclusion (equitable secondary school enrollment); (2) Environmental Sustainability with the subdimensions of air quality (PM2.5 concentration), waste management (wastewater treatment), and energy (share of renewable energy;

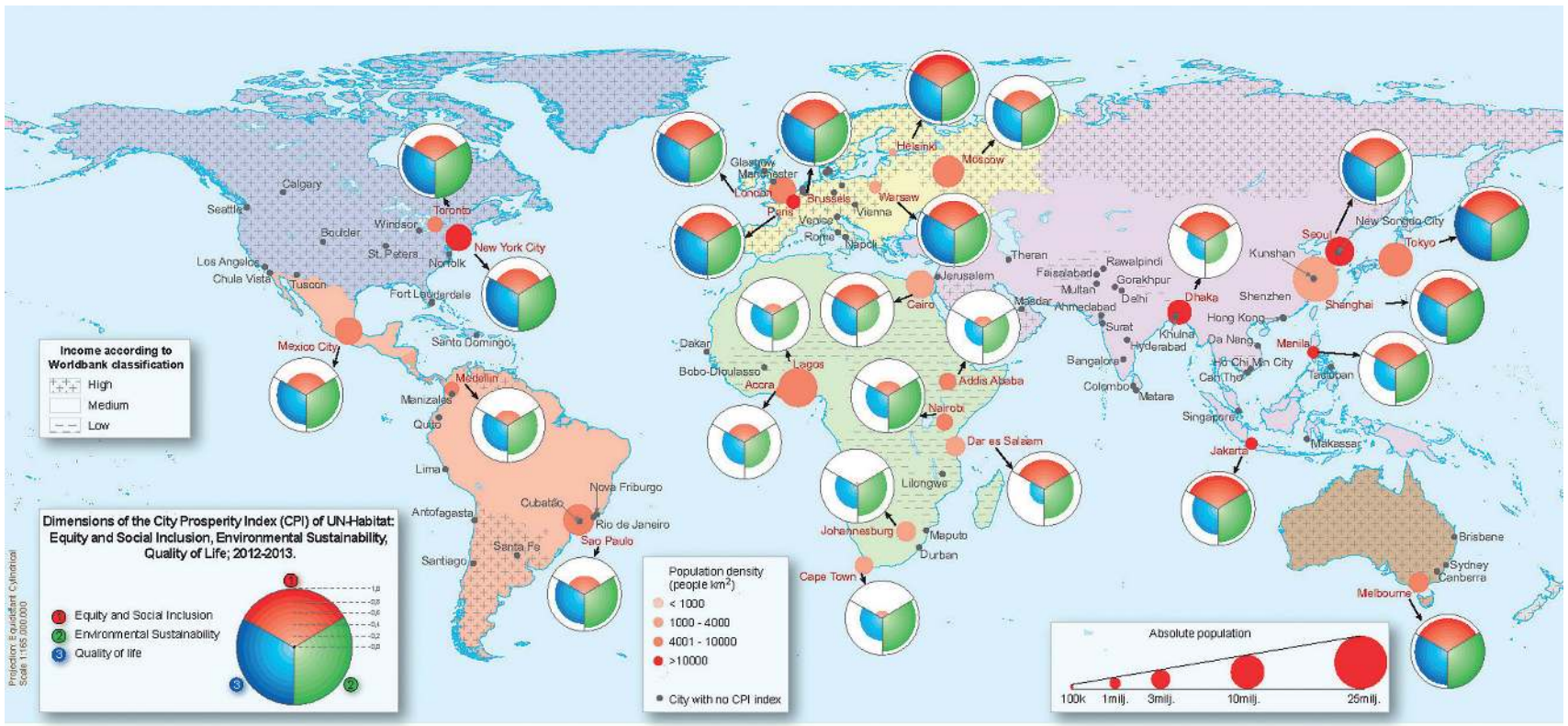


Figure 6.3 *Case study cities included in this assessment and, where available, the three dimensions of the City Prosperity Index (CPI) (2012/2013) relevant for this chapter, namely (1) Equity and Social Inclusion, (2) Environmental Sustainability, and (3) Quality of Life. The CPI is a multidimensional index, developed by UN-Habitat (2013b) and comprises six dimensions with sub-dimensions and respective indicators that are measured for cities. Data of indicators are aggregated into one single value per dimension. Indicators are standardized using internationally observed benchmarks. For further explanation see text.*

CO_2 emissions); and (3) Quality of Life, by aggregating the subdimensions of health (life expectancy at birth; under-five mortality rate), education (literacy rate; mean years of schooling), and safety and security (homicide rate). The other three dimensions of the CPI (i.e., Productivity, Infrastructure, and Governance and Legislation), are not shown (not relevant or no data).

Across the case studies represented in Figure 6.3 we see that equity and social inclusion is generally low in cities of central and southern Africa and in cities of South America. In African cities, low equity and social inclusion go along with relatively low quality of life, meaning poor health, education and safety. This is likely to be accentuated by climate change impacts, although there is low- to medium-level evidence and a low level of confidence. Dar es Salaam is an exception to the African pattern, showing relatively high equity but very low quality of life. In comparison, South American cities are able to sustain a medium quality of life despite low levels of equity, but the interactions with climate risks in these cities is uncertain.

Equity and Social Inclusion in the North American cities is higher than in the South American cities but lower than in the European cities on average. An exception for Europe marks the city of Moscow, showing a relatively low level of equity and social inclusion. Cities in Asia show a mixed picture regarding equity and social inclusion. In the cities of high-income nations, cities such as Tokyo and Melbourne, equity is high. In cities of middle-income nations, cities such as Manila, Jakarta, and Dhaka, equity is somewhat lower. In these cities (as well as in Dar es Salaam), the equity index is higher than the index for quality of life. This constellation generally shows that large parts of the urban population live in low-quality conditions.

We acknowledge that these interpretations are based on a very small sample and advise caution about any generalizations across the case study cities (based on data from UN-Habitat State of the World Cities 2012/2013 – Prosperity of Cities).

Evidence also points to the role of legal, governance, and investment practices in shaping or constructing urban risks. The disproportionate impact of extreme weather events on low-income urban populations is strongly associated with the lack of risk-reducing infrastructure (including piped water, sanitation, drainage and solid waste collection, all-weather roads and paths) and services (including health care and emergency services) (Revi et al., 2014). This disproportionate impact on low-income urban neighborhoods is often underpinned by a lack of capacity within urban governments or their voluntary refusal to address the large infrastructure and service deficits, particularly in low- and middle- but also in high-income countries. Both Hurricane Katrina in New Orleans and Hurricane Sandy in New York disproportionately impacted social groups with lower incomes and social status, particularly ethnic minorities and women (David and Enarson, 2012; Elliott and Pais, 2006; Brodie et al., 2006; Blake et al., 2013). However, risks are even higher for many residents in most cities of low- and middle-income countries and affect a greater proportion of the urban population.

Government refusal to address existing vulnerabilities leads to the social construction of risk (Eiser et al., 2012; Singh and Fazel, 2010) or "development-accumulated" risk (Satterthwaite, 2013; McBean, 2012). Some recent local initiatives have made commitments to incorporate equity and environmental justice in plans to build resilience to climate change, for example New York, 2015 "OneNYC Plan: The Plan for a Strong and Just City" (City of New York, 2015). In most cities, however, low- and medium-income neighborhoods continue to be located in hazard-prone areas as a result of historical development trajectories. Infrastructure in these neighborhoods is less resilient to climate shocks. There are usually deficiencies in risk-reducing and disaster-response infrastructure, and less attention is paid to lessons from previous disasters (Singh and Fazel, 2010) (see Chapter 3, Disasters and Risk). This has resulted in the accumulation of risk over time, documented by increasing disaster losses in cities from mega-debris flows, floods, earthquakes, tsunamis, and tropical storms in the past two decades (Allen, 2006; Annez et al., 2010; Rao, 2013).

6.2.2 Equity and Climate Hazards

6.2.2.1 Heat

Heat-related impacts are among the main hazards associated with climate change in cities. Two dynamics converge: (1) the global increase in average temperature and (2) the urban heat island (UHI) effect (i.e., the temperature gradient between dense built-up environments and rural areas around them) (see Chapter 2, Urban Climate Science). These dynamics can be beneficial when reducing the mortality and morbidity risks of cold temperatures, but often evolve into particular risk situations during periods of excessive heat or heat waves (White-Newsome et al., 2009). Heat waves are prolonged periods of heat crossing either an absolute or relative threshold above a long-term temperature average that differs by city; typical relative thresholds are two or three standard deviations above mean temperatures (Tong et al., 2010) (see Chapter 2, Urban Climate Science). Heat waves pose a major climate-related risk because more fatalities occur from heat waves than from other climate hazards such as floods and hurricanes (Satterthwaite et al., 2007; Klinenberg, 2003).

Heat waves in cities can cause increased morbidity and mortality rates as a result of direct heat stress and other indirect effects (Kinney, 2012) (see Chapter 10 Urban Health). Direct heat stress is particularly harmful when night-time temperatures are high, which prevents the human body from rest, repose, and regeneration (Amengual et al., 2014). Indirect effects on health arise through the interaction of heat and other environmental factors, particularly air and water pollution (Petkova et al., 2013; Petkova et al., 2014). For example, air pollutants and heat can cause higher ozone concentrations (Neidell and Kinney, 2010; Sheffield et al., 2011), reducing lung function and irritating the respiratory system. As a result, heat waves can cause heart attacks and aggravate asthma, bronchitis, and other cardiopulmonary diseases, leading to premature death. Effects of ozone and direct heat stress are additive (Kosatsky, 2005).

Box 6.2 Climate Change and Gender Inequality in Cities

Marcela Tovar-Restrepo

Women's Environment and Development Organization (WEDO), New York

Climate change exacerbates existing social and economic inequalities among diverse social groups. However, gender inequality is more pervasive than any other form of inequality (Brady, 2009) since it cuts across other forms of exclusion and inequity (Brady and Kall, 2008). Gender differences intersect with other identity markers such as income, ethnicity, race, religion, ability/disability, age, literacy, and geographical location. All these factors lead to differential exposure to risk, preparedness, and coping capacities to recover from climate change impacts (Chen et al., 2005; UNIFEM, 2008). Women from low- and middle-income countries living in poverty are typically more vulnerable to climate change impacts than men because of the discrimination they face with respect to wealth and capital goods, health, access to technologies, education, services and information, and opportunities to generate financial and productive assets. Due to differentiated gender roles, climate change extremes also increase the number of underpaid and nonpaid hours of care-work that women have to devote to their domestic and community spheres (Tronto, 1993; Fahmi et al., 2014). All these further challenge women to adapt to climate change and recover from impacts in cities.

To target climate change causes and consequences in a sustainable and equitable way, urban policies, plans, and projects need to be formulated to reduce *ex-ante* vulnerabilities of individuals and social groups, taking into account gender roles and women's needs. Finally, engaging at the household level and involving women in leadership roles in community organizing processes and political representation will help to develop effective coping strategies to mitigate and adapt to climate change (Alber, 2011; WEDO et al., 2013).

Box 6.2 Table 1 *The impacts of climate change events on women and girls in cities, as compared to men. Sources: GGCA, 2009; Dankelman, 2010; Tovar-Restrepo, 2010; Levy, 2013*

Climate Change Event	Impact on Cities	Impact on Women and Girls
Heat waves; flooding; land slides	**Reduced or no access to potable water, drainage, and sanitation infrastructure**	• Women are more likely to be affected from heat stress than men (see Section 6.2.1). • Women face loss of income from their home-based activities and often water-based economic activities like cleaning, washing clothes, or cooking food products, particularly in informal settlements. • Women have to spend more hours fetching water from water trucks or tanks. • Reduction in food supply or increase in food prices may cause malnutrition or low calorie intake, especially in older women and young girls because of gendered diet hierarchies. • Women overwhelmingly take care of children, old, and sick family and community members who tend to suffer diarrheal, respiratory, and other health problems, placing themselves at the risk of infections. • Immigrant women who do not speak the dominant language have less access and understanding of risks and preparedness information; they may have less education and less contact with the public sphere.
Sea level rise; hurricanes; cyclones; heavy rains	**Damage or loss of shelter, urban infrastructure, or services such as electricity, transport facilities, roads, and community public spaces**	• Women are present in greater numbers in the urban informal economic sector. The loss of small productive assets such as sewing machines from extreme weather especially impacts their home-based businesses. • Women are more vulnerable to losing their jobs given that they need to devote more time to nonpaid care-work. • Women may be more severely impacted by damages to the public transport infrastructure because they make more daily trips than men and are greater public transport users.
General	**Lack of gender-specific facilities and policies during recovery**	• Because women have less access to secure land tenure, they may be less eligible for financial credits or subsidies in climate change recovery stages. Displacement or relocation plans usually do not take into account differentiated gender needs and roles. For example, land-use planning, public space, and transportation facilities are especially central to women since they need to have access to community services and child-care facilities. In post-disaster camps and temporary accommodations, women often face serious risks of sexual harassment and violence.

Heat-related risk might be expected to impact all citizens equally because both heat and ozone affect the overall urban environment. However, heat-related risk is stratified across the population and is linked to both "intrinsic" person-specific characteristics and "extrinsic" socioeconomic factors. Intrinsic factors include physiological attributes such as age, sex, disabilities, and medical status. Extrinsic factors refer to social, environmental, and location-specific characteristics such as socioeconomic status, gender, and living and working conditions.

A meta-analysis of eighteen recent studies that allowed for consistent quantification concluded that, among intrinsic factors, age is the most determinant risk factor contributing to excess (above normal) heat-related mortality (with reported relative risk ratios [RRR][1] ranging from 1.3 to 3.7) (Gouveia et al., 2003; Pirard et al., 2005; Simón et al., 2005; Michelozzi et al., 2005; Canouï-Poitrine et al., 2005; Garssen et al., 2005; Baccini et al., 2008; Johnson et al., 2005; Yang et al., 2013; Tran et al., 2013). Only one study shows higher RRR for children in comparison to the overall population (Gouveia et al., 2003).

Females have a relatively higher risk of heat-related mortality than males (RRR = 1.0–1.4 and possibly higher) (Pirard et al., 2005; Michelozzi et al., 2005; Canouï-Poitrine et al., 2005; Yang et al., 2013; Nogueira et al., 2005). Women may be more heat intolerant than men due to potential physiological and thermoregulatory differences (Druyan et al., 2012; Racine et al., 2012). However, women may also typically experience more exposure to heat than men due to the time spent in interior spaces undertaking labor such as cooking in houses without adequate air flow or air-conditioning (Jabeen, 2014).

In terms of medical status, vulnerability to heat waves is higher in people who are less mobile and confined to bed, the latter with an odds ratio (OR)[2] of 3–9 (Semenza et al., 1996; Vandentorren et al., 2006). People suffering from cardiovascular diseases are also at relatively higher risk (OR, 4.05 for the overall population and up to 34.1 for the elderly) (Vandentorren et al., 2006; Baccini et al., 2008; Tran et al., 2013; Nitschke et al., 2013).

Extrinsic, socioeconomic factors for heat-related effects reported in the literature are mainly related to location-specific characteristics. Although data on relative risk linked to socioeconomic levels are not systematically reported, the overall trend indicates that lower socioeconomic status (using a deprivation index based on education, occupation, unemployment, number of household members, overcrowding, and household ownership data) and lower education levels increase relative vulnerability to heat stress (Begum and Sen, 2005; Michelozzi et al., 2005; Harlan et al., 2006; Yang et al., 2013). Loughnan et al. (2013) note that heat disproportionately impacts socioeconomically disadvantaged households because of their residence in areas with less access to urban green infrastructure and their reduced ability to fund, maintain, and develop private green space. The existence of open spaces and water (such as pools) are risk-reducing environments because they cool their immediate surroundings (Nogueira et al., 2005; Harlan et al., 2006).

Comparing risks across urban regions, people living in inner cities are generally more at risk than those living in the suburbs (Reid et al., 2009; Harlan et al., 2013). Specific climatic regions modify the relative risks across urban or regional areas (Michelozzi et al., 2005; Baccini et al., 2008). A study on the effects of the 2003 heat wave in Europe reported that death rates increased by 42% in London compared to an average of 16% over the whole of England and Wales (Johnson et al., 2005). This corresponds to an RRR of up to 2.6 for excess mortality in London, possibly because the UHI accentuates climatic heat stress.

Working and living conditions also influence vulnerability to heat waves (White-Newsome et al., 2012), especially due to the heat stress experienced by members of low-income households working from home. Tran et al. (2013) reported an OR of 1.86 in Ahmedabad, India (see also White-Newsome et al., 2012). People living under the roof or on the upper floor face similar high risk (RRR of 4.7 and 5.4, respectively) (Semenza et al., 1996; Vandentorren et al., 2006; Canouï-Poitrine et al., 2005). Additionally, studies suggest loneliness (among the elderly and particularly unmarried men) and related behaviors as risk factors (Canouï-Poitrine et al., 2005; Klinenberg, 2003). Considering the additive nature of intrinsic and extrinsic factors, indoor heat stress is reported to be particularly prevalent among women, children, and elderly people living in inadequate housing (White-Newsome et al., 2012).

Measures to assist populations with higher risks of heat-related mortality can address both intrinsic and extrinsic factors (see Chapter 10, Urban Health). At the intrinsic level, individuals at risk could receive special health care and broader social support (i.e., neighbors or community group members may check in on elderly living alone during periods of excessive heat). Air conditioning – although a common way of dealing with heat – is not a sustainable measure. Most current systems consume electricity and, if generated from fossil-fuels, contribute to GHG emissions. Moreover, purchase and running costs may prohibit use by many poorer residents. To add to this, extreme heat can often produce electricity black-outs or brown-outs, resulting in the unavailability of air conditioning altogether. Urban planning and public health managers may therefore provide more effective support to poorer households with measures at the extrinsic level. This includes traditional and new adaptive architecture in areas with high risk and technology that cools rather than traps heat (e.g., through albedo modifications, greening, and landscape planning) (see Chapter 5, Urban Planning and Design).

1 When two groups were compared (e.g., the elderly with the overall population; or women and men), relative risk ratios (RRR) are calculated from the difference of mortality risk between the two groups, given as ratio of the percentages of excess of mortality.

2 Odds ratios (OR) are calculated as the risk of death among subjects as compared with those without the characteristic in question.

6.2.2.2 Rain

Precipitation-related hazards present a range of significant risks to human well-being, such as those connected to inland flooding, landslides, and drought. Inland flooding can occur on a massive scale – as in Pakistan in 2010 (Atta-ur-Rahman and Khan, 2013), Australia in 2011 (Coumou and Rahmstorf, 2012), and Thailand in 2011 (Komori et al., 2012) – but localized floods can also cause substantial damage and threaten health, lives, and livelihoods. In many cities, informal settlements have arisen on flood plains that experience regular flooding or on steep slopes where heavy precipitation regularly triggers dangerous landslides (Dodman, 2013; Carcellar et al., 2011; Moser and Stein, 2011; Hardoy and Pandiella, 2009; Douglas et al., 2008b; UNISDR, 2009, 2011). However, insufficient precipitation and rainfall that is mistimed relative to the agricultural growing season can also severely impact urban residents since these events can cause water shortages, crop failures, and food price increases, with negative consequences for low-income populations.

6.2.2.3 Inland Flooding

Urban flood risk in low- and middle-income countries stems from a number of factors: impermeable surfaces that prevent water from being absorbed and instead cause rapid run-off, the general scarcity of parks and other green spaces to absorb such flows, inadequate drainage systems that are often clogged by waste and quickly overloaded with water, and the ill-advised development of housing on marshlands and other natural buffers (Jha et al., 2012; Revi et al., 2014).

The urban poor are often more exposed than other city dwellers to these environmental hazards because the housing they can afford tends to be located in environmentally riskier areas (such as floodplains and slopes) and of poorer quality, and because municipal governments overseeing such neighborhoods often fail to establish and maintain proper drainage and waste collection and disposal. According to the Asian Development Bank (ADB) (2010), 40% of urban dwellers in Asia can be classified as living in substandard housing or slums, which are often found along a city's rivers and canals – areas that tend to be publicly owned and thereby typically less problematic to settle on than private land (Taylor, 2013). Living close to urban waterways is in many instances a consequence of the pressure for land in fast-growing cities and can be attributed to a lack of tenure security for the urban poor and new migrants, in turn leading to population displacement and the disruption of livelihoods and social support networks when flooding reoccurs (Hardoy and Pandiella, 2009). Other indirect effects are related to poor-quality housing and unsanitary conditions (Haines et al., 2013). For example, when flooding occurs, hazardous materials frequently contaminate open waters and wells, elevating the risks of water-borne, respiratory, and skin diseases (Ahern et al., 2005; Kovats and Akhtar, 2008; Akanda and Hossain, 2012; Khan et al., 2011) (see Chapter 10, Urban Health).

6.2.2.4 Landslides

Landslide risks have not received as much attention as flooding and coastal hazards. Cepeda et al. (2010) note that landslides are usually not separate from other natural hazard triggers, such as extreme precipitation, earthquakes, or floods in the natural disaster databases. This contributes to reducing the awareness and concern of both authorities and the general public about landslide risk. Yet in many cities, landslides present significant threats to human well-being.

Rainfall-triggered landslides are the product of a combination of geo-hydrological and locational factors. Geo-hydrological factors refer to duration and intensity of precipitation. Locational factors include slope, rock strength, rock susceptibility to fracturing, soil moisture, and vegetation cover, as identified in risk analyses carried out in Indonesia (Cepeda et al., 2010) and El Salvador with comparisons to Nepal and Sri Lanka (NGI, 2012). Both these studies drew on DESINVENTAR[3] data on the occurrence of rainfall-induced landslides and compared them to population density and socioeconomic composition. However, when holding geo-hydrological exposure constant, the studies reached different conclusions.

In El Salvador, better-off municipalities experienced greater landslide mortality than did less well-off ones. By contrast, the Indonesian analysis found the expected negative association between the Human Development Index (HDI) and landslide mortality, net of physical exposure. These examples – based on similar methods – underscore the need for caution in making generalizations about the nature of the poverty–hazard vulnerability relationship with regard to landslides.

The need for caution also extends to policy measures driven by equity concerns. Well-intentioned infrastructure measures and public policies to protect or upgrade settlements may actually increase risk in these or adjacent neighborhoods. For example, in Medellín, infrastructure improvements are criticized as detrimental to environmentally protective infrastructure such as parks on hill slopes that reduce the risk of landslides and flooding (Drummond et al., 2012; Guerrero, 2011). In Rio de Janeiro, the paving of walkways in *favelas* as part of slum upgrading has increased runoff to the low-lying areas (de Sherbinin and Hogan, 2011). In Rio, several studies that have focused on modeling landslides converge on the nexus between slope instability, rainfall intensity, and soil hydrology as determinants of landslides (Moreiras, 2005). This is true whether the slopes are disturbed or not (Caine, 1980). The convergence of geophysical factors with locational factors (in turn related to patterns of deprivation) distributes landslide risk inequitably. Historical conflicts and control of some areas by organized crime gangs notwithstanding, public policies and low infrastructure investments raise equity issues in these cities and poorer neighborhoods.

3 www.desinventar.org/

6.2.2.5 *Drought*

It is seldom appreciated that many cities in low- and middle-income countries are located in dryland ecosystems, where precipitation is low but can also be erratic and unpredictable. McGranahan et al. (2005) estimated that about 45% of the population living in drylands is urban. Safriel et al. (2005) estimated that drylands ecosystems cover 41% of the Earth's surface while providing a home to some 2 billion people. Low- and middle-income countries account for about 72% of the land area and some 87–93% of the population of the drylands.

Drought can have many effects in urban areas, including increases in water shortages, electricity shortages (where hydropower is a source), water-related diseases (through use of contaminated water), and food price increases due to reduced supplies (Revi et al., 2014). An estimated 150 million people currently live in cities with perennial water shortages, defined as less than 100 liters per person per day of sustainable surface and groundwater flow within their urban extent. This may increase to up to 1 billion people by 2050 (McDonald et al., 2011).

Among the people estimated to live with perennial water shortages in the future, women are likely to be disproportionally represented because they often belong to the poorest of the poor. Many of the described impacts, particularly increased food prices and food insecurity in cities, will disproportionally impact women because they reduce food intake compared with other family members if food is scare and/or expensive (GGCA, 2009).

Urban risks of drought and water shortages are likely to be accompanied by intense, damaging rainfall events. As Safriel et al. (2005) note, in dryland ecosystems the expected annual rainfall typically occurs in a limited number of intensive, highly erosive storms. For example, in the Sahel, Descroix et al. (2012) describe a severe flood that affected the middle Niger River valley in 2010, inundating 3.1 square kilometers of the city of Niamey, where an estimated 5,000 people lost their homes. The trigger was damaging intense rainfall, which is infrequent but not unusual in the Sahel dryland areas, while the damaging impact was mainly attributed to land-use changes in the region. Another example refers to São Paulo, where downpours caused severe flooding in the midst of a serious drought in February 2015. In just one hour, São Paulo experienced 96 millimeters of rainfall while at the same time undergoing the most severe drought in the past eighty years (Fox, 2015). Ironically, while leaving the city under water and causing substantial traffic disruptions, the amount of rainfall was not enough to replenish the city's reservoirs further away from the urban area, and water rationing had to continue.

If droughts occur in combination with other extreme events, they increase the knock-on effects of disasters and cause cumulative impacts because cities may still be struggling to recover from the previous event (Kates et al., 2012). Intensive flooding as a result of heavy rainfall during droughts is one example; the risk of fires for heat-sensitive ecosystems in water-stressed cities is another (Ziervogel et al., 2010). Cape Town is an example where droughts increase the risk of fires in the surrounding heat-sensitive ecosystems (Jenerette and Larsen, 2006; Vairavamoorthy et al., 2008).

Moreover, uncertainties about long-term drought risk from climate change may have an influence on current access to water in cities, as observed in Mexico City (Romero Lankao, 2010). This raises equity issues because the poor are reported to spend from 4.2% to 4.7% of their income on water, whereas rich people pay 0.4% to 0.5% and consume more than twice as much water (Olmstead et al., 2007; Ruijs et al., 2008); though percentages differ across countries. Literature suggests the need for progressive block prices, full-cost prices, and income-dependent price systems and not egalitarian pricing systems (Olmstead et al., 2007). However, increasing block rates (prevalent in Europe) may have negative impacts on the welfare of low-income groups in the long run when structured on a volume basis rather than per-capita (Bithas, 2008). Similarly, availability of treated water (and thus of water treatment plants) is also unequal and positively correlated with income levels (Awad, 2012).

6.2.2.6 *Storm Surge and Coastal Flooding*

Storm-related hazards (tropical and extratropical cyclones and storm surges) are often connected to precipitation-related hazards and constitute major risks to urban populations. In coastal regions, global warming–induced sea level rise, combined in places with subsidence of coastal land and increasing storm intensity, put large coastal populations at risk from storm surges (see Chapter 9, Coastal Zones). Recent examples of coastal flood disasters include the flooding caused by Hurricane Katrina in New Orleans in 2005, Cyclone Nargis in southern Myanmar in 2008, Hurricane Sandy in New York in 2012, and Super Typhoon Haiyan in the Philippines in 2013 (Temmerman et al., 2013). Hurricane Katrina reached up to 10 meters (Fritz et al., 2007) and Hurricane Sandy to almost 4 meters above normal tide levels (Blake et al., 2013; McGranahan et al., 2007; IPCC, 2007).

Urban dwellers are more likely than rural villagers to be exposed to the risks of cyclones and storm surges because urbanites are more likely to live on or near the coast: cities and towns account for nearly two of every three residents of coastal areas worldwide (McGranahan et al., 2005; McGranahan et al., 2007). In Asia, 18% of the population lives in the low-elevation coastal zone – the highest percentage across all world regions – and 12% of the urban land is at low elevation and near the coast (McGranahan et al., 2007). Moreover, many of Asia's largest cities are located in coastal areas that are cyclone-prone, such as Mumbai, or Karachi (World Bank, 2008; Kovats and Akhtar, 2008). Flooding and storm surges also threaten coastal African cities, such as Port Harcourt and Lagos in Nigeria (de Sherbinin et al., 2014; Güneralp et al., 2015) (see Box 6.3). Similar vulnerabilities affect Mombasa and various cities in Latin America (Douglas et al., 2008a; Awuor et al., 2008; Hardoy and Pandiella; 2009; Revi et al., 2014).

Vulnerable people and households are more likely to be affected during extreme weather events, such as hurricanes and storm surge flooding (Hartman and Squires, 2006; Cutter et al., 2006), partly because these groups live disproportionately in low-lying areas and flood plains in many world regions, as documented from various cities in Africa, Asia, and Latin America (Hardoy et al., 2001; Balk et al., 2009). Vulnerable people and households, such as women with low incomes or ethnic minorities, also possess substantially fewer resources to cope if damage occurs. For example, Hurricane Katrina disproportionately affected African-American residents and elderly people (Hartman and Squires, 2006; Cutter et al., 2006; Curtis et al., 2007). Case studies suggest that mortality rates of women and men vary significantly for both climatologic and other natural disasters. During the cyclone in Bangladesh in 1991, death rates were 71 per 1,000 for women and 15 per 1,000 for men. In the 2004 Tsunami in Amapara, Sri Lanka, fatalities were 3,972 and 2,124 among women and men, respectively (David and Enarson, 2012).

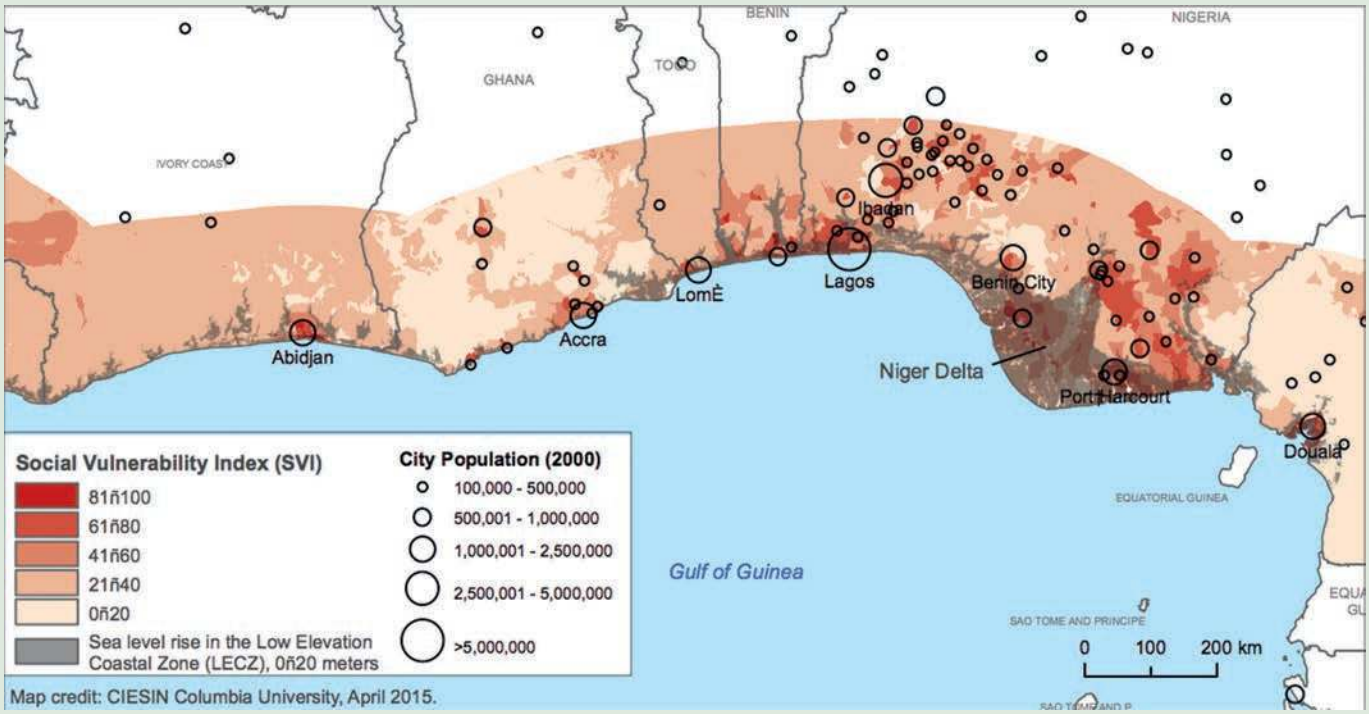
In addition to human fatalities and infrastructure damages, a number of health risks are associated with coastal (and inland) flooding, such as cholera, cryptosporidiosis, typhoid fever, diarrheal diseases, and leptospirosis (Kovats and Akhtar, 2008) (see

Box 6.3 Mapping Exposure to Coastal Stressors, Social Vulnerability, and Population Growth in West Africa

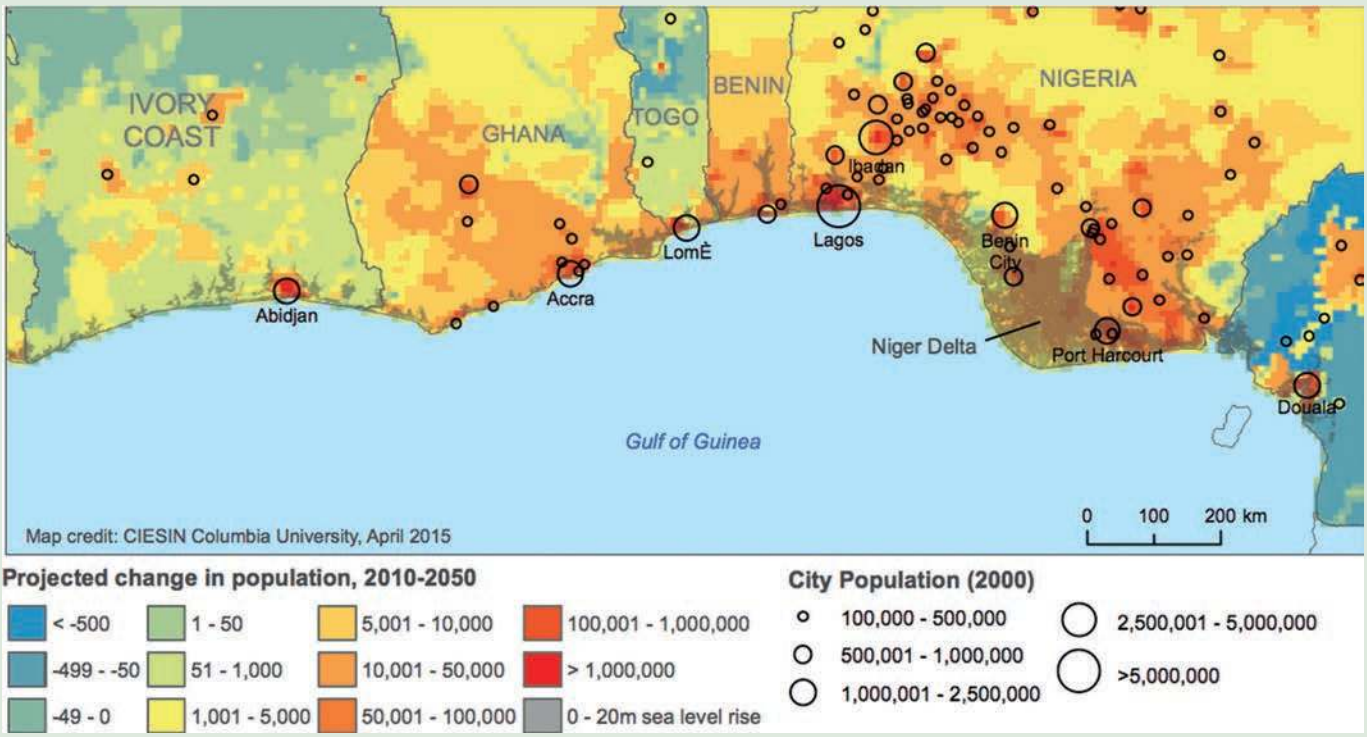
The African Resilience to Climate Change project mapped the exposure of coastal systems and vulnerable populations to projected sea-level rise along the West African coast (de Sherbinin et al., 2014).

Results show areas of high social vulnerability and high exposure, particularly in the Niger Delta, Lagos, Cotonou (Benin), and Abidjan. These same areas are projected to see high levels of population growth. Projections to 2050 in the near coastal zone (0–5 m elevation) suggest a more than threefold increase in population (from 15 to 57 million people), with most of that concentrated in Nigeria. For the 0–20 meter low elevation coastal zone, the projected increase is from 33 million to 115 million people, most of them urban residents. Climate change and associated sea level rise will put substantially more socially vulnerable people at risk along the West African coast in the future.

A composite social vulnerability index (SVI) was constructed from indicators representing population density, population growth (2000–2010), subnational poverty and extreme poverty, maternal education levels, market accessibility, and conflict events (de Sherbinin et al., 2014). Population projections to 2050 used Shared Socioeconomic Pathway 4, representing a socially divided world with high levels of rural-to-urban migration (Riahi et al., 2017).



Box 6.3 Figure 1 *Social vulnerability index, low-elevation coastal zones (<20 m above sea level) and location of large urban areas along the coast of West Africa.*



Box 6.3 Figure 2 *Projected population change to 2050, low elevation coastal zones and location of large urban areas along the coast of West Africa.*

Source: Adapted from de Sherbinin et al., 2014

Chapter 10, Urban Health). Lau et al. (2010) suggest that the combination of climate change, flooding, population growth, and urbanization will almost certainly lead to an escalation of leptospirosis, with high risks for urban slums, low-lying areas, and small island states. Storms are also expected to lead to water contamination with chemicals, heavy metals, and other hazardous substances for populations living near industrial areas on the coast (see Case Study 6.1). Moreover, Smith et al. (2014b) describe a newly emerging literature on the mental health consequences of flooding and other extreme events (see also Kinney et al., 2015).

Case Study 6.1 Building Climate Justice in New York: NYC-EJA's Waterfront Justice Project, The Sandy Regional Assembly, and the People's Climate March

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Keywords	Environmental justice, climate justice, storm surge, Waterfront Justice Project, Sandy Regional Assembly, People's Climate March
Population (Metropolitan Region)	20,153,634 (U.S. Census Bureau 2016)
Area (Metropolitan Region)	17,319 km^2 (U.S. Census Bureau, 2010)
Income per capita	US$53,380 (World Bank, 2017)
Climate zone	Dfa – Cold, without dry season, hot summer (Peel et al., 2007)

Coastal storms, storm surge, and extreme winds all pose risks to urban coastal populations in most low-, middle-, and high-income countries in the future. For example, climate change projections suggest that, in the North Atlantic, the most intense hurricanes will increase in frequency by the 2050s (NPCC2, 2013), whereas the number of hurricanes might remain relatively unchanged. The combination of extreme weather events and climate change is creating new challenges for environmental justice for many communities living along industrial waterfronts.

Industrial waterfront communities have historically been the site of clusters of polluting industry and infrastructure. For instance in New York, most manufacturing zoning districts are located along the waterfront and have been linked with the inequitable distribution of noxious matter in these communities (Maantay 2002; Fahmi et al., 2014). However, research addressing the impacts of climate change, storm surge, and extreme winds on these waterfronts and the risks to low-income communities and communities of color living in close proximity to them is lacking. Therefore, environmental justice communities in New York are working to (1) conduct research to the threats in their communities; (2) identify proactive policies and programs to promote climate resilience

that reflect local priorities; and (3) build climate-resilient industrial waterfronts while preserving jobs.

In 2010, the New York City Environmental Justice Alliance (NYC-EJA) launched the Waterfront Justice Project, a research and advocacy campaign to promote climate-resilient industrial waterfront communities. NYC-EJA's research has focused on six Significant Maritime and Industrial Areas (SMIAs), where industrial uses and public/private infrastructure are clustered and that are located in areas at risk of storm surge and high winds as projected by the New York State Office of Emergency Management. The majority of those vulnerable areas are in Brooklyn (NYC-DOHMH, 2010), including some SMIAs located within the 100-year floodplain of the Federal Emergency Management Agency (FEMA) and therefore at particular risk of rising sea levels. By 2050, sea levels are projected to rise by at least 2.5 feet (NYC-SIRR, 2013; NPCC2, 2013).

Before the launch of NYC-EJA's Waterfront Justice Project, the City of New York had not considered the risk of toxic exposures associated with clusters of heavy industrial uses in such vulnerable locations. After five years of research and advocacy work by NYC-EJA, the NYC Panel on Climate Change has incorporated potential hazardous exposures that can occur in the event of severe weather as an important threat affecting industrial waterfront communities that are vulnerable to climate change impacts (Kinney et al., 2015).

Low-income residents and people of color in the communities who live and work in and around the SMIAs are especially vulnerable to the potential release of contaminants in the event of strong winds, flooding, and storm surges, which are projected to increase in severity and frequency. According to the 2010 U.S. Census, approximately 622,600 New Yorkers lived in census tracts that fall within a half mile of the SMIAs and are vulnerable to storm surge. Of that number, approximately 430,000 are people of color (U.S. Census Bureau, 2010b). In addition, these areas present some of the highest levels of uninsured populations, implying limited access to health care in the event of toxic exposures (NYC-DOHMH, 2010). NYC-EJA has successfully advocated for changes in the City of New York's updated Waterfront Revitalization Program (i.e., NYC's official coastal zone management plan) and initiated conversations with local policy-makers, government agencies, residents, and businesses. The Waterfront Justice Project is increasing awareness of hazardous substances in the context of climate change impacts to industrial waterfront neighborhoods in New York (Bautista et al., 2014). NYC-EJA's Waterfront Justice Project shows how affected communities are leading the call to integrate climate adaptation and pollution prevention into planning and development strategies in industrial waterfront communities.

After Hurricane Sandy, NYC-EJA extended this work to participate in the recovery planning process by co-convening the Sandy Regional Assembly, a coalition of community, environmental justice, labor, and civic groups from NYC, Long Island, and New Jersey. The Sandy Regional Assembly participated in the recovery process by advocating for green infrastructure and climate adaptation projects in low-income communities and communities of color, commenting on government reports, and promoting community-driven resiliency planning across the New York-New Jersey region.

In that mission, NYC-EJA was a co-coordinator of the massive People's Climate March in September 2014 (see Case Study 6.1 Figure 1) – at the time, the largest climate march in history – with an estimated 400,000 participants, 1,500 organizational sponsors, and more than 2,000 solidarity marches and rallies across the globe. NYC-EJA helped build this diverse mobilization of labor unions, environmental justice organizations, social justice, community-based

Case Study 6.1 Figure 1 *People's Climate March in New York, September 21, 2014.*

Photo: Climate Action Network International

organizations, faith-based organizations, and environmentalists (Bautista et al., 2015).

In April 2016, NYC-EJA released *The NYC Climate Justice Agenda: Strengthening the Mayor's OneNYC Plan* (NYC-EJA, 2016). This was the first comprehensive analysis of Mayor de Blasio's *OneNYC: The Plan for a Strong and Just City* (City of New York, 2015) from an environmental/climate justice perspective. The Mayor's Office publicly welcomed this partnership and has been exploring opportunities for further collaboration to continue advocating for the implementation of NYC-EJA's efforts to address environmental justice issues in New York.

6.2.3 Equity in Relation to Urban Climate Change Adaptation

Equity and environmental justice issues related to climate change in cities include inequalities in the capacity to cope and adapt, which in particular affects low-income groups (Dodman, 2013; Hardoy and Pandiella, 2009). This section focuses on inequality in relation to urban risks arising from the failure to adapt, inadequate adaptation, or maladaptation to climate change.

Differentials in the scale and nature of risks among settlements relate to the extent of infrastructure and services provision (see, e.g., Krishna et al., 2014, for a discussion on infrastructure and service provision among different informal settlements in Bengaluru). Differentials in risk arising from inadequate or no infrastructure and services can emerge in relation to age, sex, and health status (Bartlett, 2008) but can also be socially constructed, as in the case of discrimination (e.g., by gender; Dankelman et al., 2008). An analysis of the impacts of floods in Lagos in 2011 revealed differences in vulnerability among low-income women created by the intersection of gender relations and gender roles in household structure, occupation, and access to health care (Ajibade et al., 2013). Differentials in risk also arise from the lack of voice for particular groups (e.g., informal settlers) and the lack of accountability to them by government agencies (Bulkeley et al., 2014; Adger, 2013). It is thus relevant to consider the extent to which adaptation measures acknowledge these differentials, identify the groups most at risk, and take action to reduce them.

Within almost all cities in high-income countries, development has greatly reduced risk from extreme weather. There is universal provision for piped treated water, adequate drainage, and implemented building standards for structural safety. Cities in high-income countries have citywide sewer systems and storm drains with the capacity to cope with extreme precipitation as well as all-weather roads, health care systems, and emergency services with little or no "inequality" in their provision as these serve everyone (see Figure 6.3). These services are not provided as a response to climate change and therefore not "adaptation" *per se*, but they promote resiliency to climate change impacts, and strengthen the institutions and financial systems that make resiliency possible (Satterthwaite, 2013). In well-governed cities, there may be high levels of inequality in income, assets, and the quality of housing and urban services between favorable and unfavorable locations, but far less inequality in benefits from risk-reducing infrastructure and services and thus in exposure to risks from climate change. This includes groups generally considered vulnerable because the universal provision of infrastructure and services reduces or removes exposure to risks. This, however, is not to claim that all inequalities in risk are addressed, as work on environmental justice has shown (Schlosberg and Collins, 2014).

The disproportionate impacts of extreme weather events on low-income populations in urban centers in low- and most middle-income countries are strongly associated with the lack of risk-reducing infrastructure (piped water, sanitation, effective drains, all-weather roads and paths) and risk-reducing services (including health care and emergency services) (Revi et al., 2014; Dodman and Satterthwaite, 2009). The lack of risk-reducing infrastructure is often underpinned by a lack of capacity within urban governments to address infrastructure and service deficits (Parry et al., 2009). In low-income and many middle-income nations, most urban authorities have very small budgets and even less investment capacity (UCLG, 2014). Housing development on dangerous sites – especially in flood plains, alongside rivers, or on steep slopes (Hardoy et al., 2001; Hardoy and Pandiella, 2009; Dodman, 2013) – is exacerbated by inappropriate building regulations and land-use/zoning practices that restrict the supply of affordable housing plots (Aylett, 2010; Lwasa and Kinuthia-Njenga, 2012; Lwasa, 2012). Undefined property rights and land tenure also contribute, as documented in cities like Nairobi, Dar es Salaam, Dhaka, Dakar, Maputo, Manila, and Kolkata (Dodman, 2013; Hardoy and Pandiella, 2009; Jenkins, 2000; Owens, 2010; Rao, 2013; Roy, 2009).

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) highlights the wide variety of urban areas' adaptive capacity (Revi et al., 2014). At one extreme, there are a billion people living in urban centers with very little capacity to adapt to climate change and with large deficits in risk-reducing infrastructure and services. Another 1.5 billion live in urban centers with limited capacities and significant infrastructure and service deficits, whereas a very small proportion of the world's urban population live in urban centers with universal provision for risk-reducing infrastructure and services and active climate change adaptation policies.

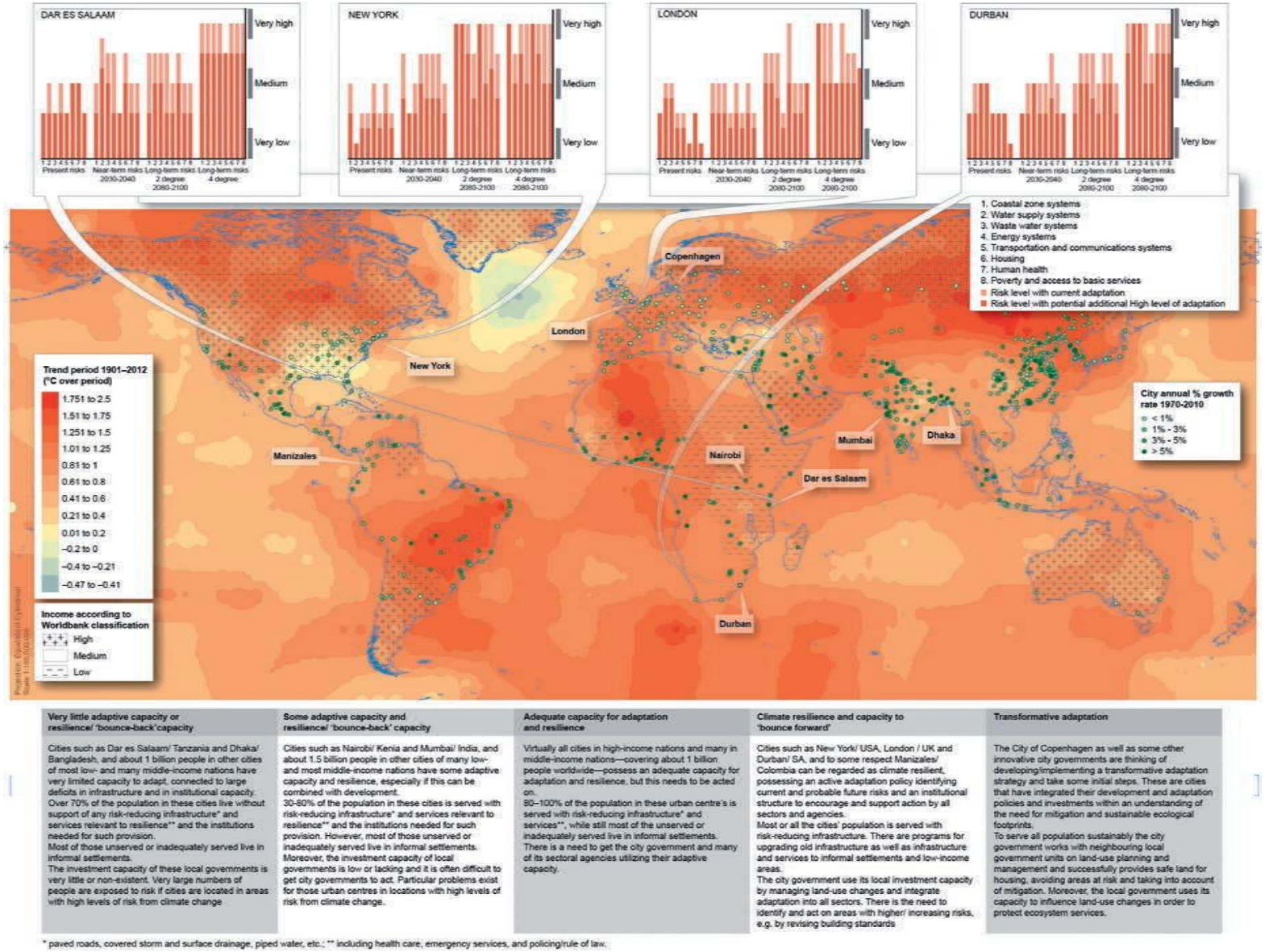

Figure 6.4 *The location and annual growth rates of large urban agglomerations against the background of recently observed temperature change. Insets (above) show current and future climate change risks in selected urban areas and (below) describe the spectrum of adaptive capacity in urban centers. (1) The map shows large urban agglomerations in 2010 across the globe and their population growth rates (1970–2010) against observed climate change (trend period 1901–2012). Many cities with the highest population growth rates are located in areas of moderate recent temperature increase, but many of them are also in low- and middle-income nations with low adaptive capacity. (2) The bar charts above the map show key climate risks to urban systems and services with and without adaptation for Dar es Salaam, New York, London, and Durban. Risk levels are identified based on an assessment of the literature and expert judgments by the Intergovernmental Panel on Climate Change, AR5, WGII, and Chapter 8 authors (Revi et al., 2014), ranging from very low to very high. For the near-term era of committed climate change (2030–2040), projected levels of global mean temperature increase do not diverge substantially across emission scenarios. For the longer-term era of climate options (2080–2100), risk levels are presented for global mean temperature increases of 2°C and 4°C above pre-industrial levels. For each time frame, risk levels are estimated for a continuation of current adaptation (pink bars) and for a hypothetical highly adapted state (red bars). Please note that the climate risks should be compared across time for each city individually; cross-city comparisons are difficult. (3) Risk levels of the selected cities can be compared to the large spectrum in adaptive capacity of urban centers to adapt to climate change as highlighted in the bottom table.*

Source: Adapted by authors with data from Revi et al., 2014

Figure 6.4 shows the risk levels for a range of key sectors for New York, London, Dar es Salaam, and Durban and their potential to adapt to current levels of risk and those anticipated in the near-term (2030–2040) and long-term (2080–2100) future, using scenarios of 2°C and 4°C warming above pre-industrial levels. Perhaps not surprisingly, risk levels increase dramatically for all key risks in the long-term, especially for the 4°C warming. But, at least for now, in the near-term, and mostly for the long-term with a 2°C temperature rise, a high level of adaptation can keep risks down. For example, in the case of Dar es Salaam (see Case Study 9.6) adaptation can potentially be effective in protecting energy and transport systems, safeguarding human health, and maintaining progress on poverty reduction. Currently, however, only a small proportion of the city's population has piped water supply to their home, sewers, covered drains, and solid waste collection; the city lacks the capacity to address these issues and implement other urgently needed adaptation measures. Dar es Salaam is an example with a large gap between adaptation needs and adaptive capacity (Kiunsi, 2013). However, under a 4°C temperature rise, adaptation measures are likely to be ineffective not only in Dar es Salaam but also in cities with currently high levels of adaptation, such as New York and London.

Changes in land-use planning and regulatory frameworks (for buildings, infrastructure, and zoning) are an important part of adaptation to climate change, as are fiscal incentives and infrastructure investments that respond to current and projected future climate risks (see Chapter 7, Economics, Finance, and the Private Sector). Land-use planning and management should play critical roles in ensuring there is sufficient land for housing that avoids dangerous sites and in protecting ecological services and systems. There is also growing awareness of the need for gender-sensitive adaptation processes and intersectional analyses in order to develop inclusive, contextually specific interventions and policies (Alston, 2013; Sultana, 2013; Kaijser and Kronsell, 2014). Adaptation practices also need to intersect with mitigation concerns (see Chapter 4, Mitigation and Adaptation). If these aspects, are covered, the IPCC AR5 speaks of transformative adaptation (see Figure 6.4; Revi et al., 2014; and Chapter 1, Pathways to Urban Transformation).

It is not only inadequate government capacity that underpins lack of attention to climate change adaptation but also deliberate choices by city or national governments (Bulkeley et al., 2014). Thailand's flood crisis in 2011 is an example of how policy interventions translate into a redistribution of risks. When city officials in Bangkok sought to protect the city center by diverting floodwaters to other areas, it heightened the disproportionate impact on those suburbs and communities outside the defenses (Nabangchang et al., 2015). The refusal to address risks to poor and politically underrepresented groups in urban areas is often related to the low priority that national governments and international agencies have given to such equity issues.

A concern for equity in climate change adaptation also means a concern for avoiding maladaptation in policies, public investments, and responses to climate risks. For example, the choices made in the management of floodwaters in and around Bangkok could be considered maladaptive practice because it protected

Case Study 6.2 Citizen-led Mapping of Urban Metabolism in Cairo

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Keywords	Participatory mapping, heat waves, urban metabolism, research justice, environmental justice
Population (Metropolitan Region)	14,629,360 (Cairo Governorate, 2014)
Area (Metropolitan Region)	4,692.7 km^2 (Cairo Governorate, 2014)
Income per capita	US$11,110 (World Bank, 2017)
Climate zone	BWh – Arid, desert, hot (Peel et al., 2007)

Cairo, the cultural and economic capital of Egypt, is the largest city in the Middle East and Africa. With a population of approximately 20 million people and three governorates, the continued expansion of Cairo has created multiple stressors on the environment, quality of life, and existing infrastructure.

Traffic congestion by the nearly 5 million cars on its roads, coupled with unregistered smelters and other industries, has resulted in Cairo having one of the highest pollution rates of any city second only to Delhi. This will be further exacerbated by the effects of global climate change, which are projected to include sea level rise into Egypt's fertile Delta region and freshwater scarcity from desertification.

Informal areas, which house approximately 60% of the city's population, are anticipated to be highly vulnerable to increasing heat waves. Such areas also tend to be the most densely populated in a city that averages 89,000 people per square kilometer (Khalil, 2010). The degree of urban consolidation can pose challenges for mitigation and adaptation measures in response to climate change.

The Eco-Citizen World Map Project (EWMP) comprises three distinct yet interwoven components: the Partnership, the Platform, and the Pedagogy. The Partnership is led by U.S. nongovernmental organization (NGO) Eco-City Builders and joined by ESRI, the Association

of American Geographers, Eye on Earth (a partnership of UNEP, Abu Dhabi Global Environmental Data Initiative), Cairo University, Mundiapolis University, University of California at Berkeley, local NGOs, and community partners.

The Platform of EWMP provides the incentive and understanding for communities to crowdsource urban data and holistically assess the condition of their neighborhoods. This promotes more democratic and grassroots leadership in proposing and planning interventions that directly enhance the sustainability and equitability of cities. Geographic information systems (GIS) and urban metabolism information systems (UMIS) are the two primary methods employed for organizing and displaying data through the Platform. UMIS describes a system, along with all of its components, to account for and analyze resource flows as they move from the natural (i.e., a source) through the built (i.e., a city) back to the natural environment (i.e., a sink). Sankey diagrams are a means to represent this, whereby the width of arrows in a linear flow is proportional to their quantity (Google Developers, 2015). The Platform displays data in visually accessible ways that communities can customize and interact with directly – specifically, spatially dynamic online maps with multiple dataset layers and Sankey diagrams.

The Pedagogy of EWMP is defined through a research justice framework, breaking down existing structural barriers between researcher and researched, and it includes a training-of-trainers methodology to support capacity-building among students and citizens. These trainers then engage in knowledge-transfer activities with citizens, thus facilitating bottom-up data collection, analysis, and publication for the Platform.

The Project's piloting in Cairo, established in early 2014, has been led in part by El-Balad, a local community-based organization (CBO) in the neighborhood of Imbaba. As one of the most densely populated informal areas in Egypt, Imbaba is among the oldest districts to host rural immigrants. Originally, Imbaba was agricultural land, subdivided illegally and built by local inhabitants. The area has since been consolidated and is a preferred destination for low- to middle-income households given its proximity to other Cairene districts and low rental costs. The Project involves El-Balad mobilizing citizens through its existing networks and students at Cairo University being trained on adapting and applying public participation techniques, GIS, and UMIS by academic faculty and the EWMP Partnership.

The students participate in labs, lectures, and group activities that touch on these topics. A community roundtable invites elders, youth, and leadership from the selected study area to a presentation on the EWMP. The event includes a discussion that refines the purpose, scope, preferred decision-making models (e.g., consensus-based), study area boundaries, data-reporting standards, and ownership of research outcomes. At the Imbaba roundtable, the community prioritized concerns around access and quality of freshwater supply. The roundtable is also an opportunity to propose realistic targets, relevant indicators, and forms of participation for data collection, input, and analytical processes. Examples of specific activities can include training on GPS devices, co-facilitation methods, computer data entry, digitizing, and geocoding techniques.

An intensive session is held as a two-day training-of-trainers event where the CBO and students facilitate workshops and initiate the citizen-led collection of data (Case Study 6.2 Figure 1). Teams are arranged according to different collection methods: namely, environmental assessments (e.g., air and water quality tests), quality-of-life questionnaires, and parcel audits of resource management such as water demand. At the designated workstations set up within the study area, data are digitized, samples are tested against established baselines, and results are analyzed.

Data for Imbaba published through the Platform have brought attention to water quality, access, and management issues. In terms of the former, quality testing has revealed an increase in the percentage

Case Study 6.2 Figure 1 *Intensive training presentation in neighborhood of Imbaba, Cairo.*

Case Study 6.2 Figure 2 *Awareness flyers to reduce water consumption.*

of coliform bacteria as a result of broken piping infrastructure that mixes potable water and sanitary streams, as well as an increase in copper traces due to old piping infrastructure and minimal storage maintenance.

In terms of management, parcel audits have shown poor water flow from the main supply lines and the disproportionate use of water demand according to building archetypes. This presents citizens with visual guides to suggest areas for conservation (e.g., minimizing use in cooking), efficiency (e.g., low-flow shower heads), cascades (e.g., gray water use for rooftop gardens), and advocacy for municipal upgrades of upstream infrastructure (e.g., retrofitting crumbling concrete plumbing with more enduring materials to minimize water loss) (see Case Study 6.2 Figure 2). A series of printed materials and awareness events organized by El-Balad and the students disseminated the pilot study results and ensured transparent flow of data to the local community.

As an initial intervention, participants formed an advocacy group to mobilize funds for household interventions and to push for governmental financing of upgrades to the area's water network.

The EWMP helps ensure equitable and grassroots interventions to reduce Imbaba's vulnerability to climate change. Technical capacity gained through the process has enabled the group to approach other informal areas including Gezirat Al-Dahab and Warak, Giza.

the wealthy and placed an increasing burden on the more vulnerable in society (see also McEvoy et al., 2014, for examples in Vietnam and Bangladesh). Other maladaptive practices relate to constraining land supplies, forcibly resettling people in areas far from their employment, or evicting people with no compensation and pushing up land and housing costs. These practices are likely to increase the proportion of the population living in vulnerable conditions and informal settlements. Maladaptation leads to further impoverishment of vulnerable groups, often in the name of "development," when low-income households are displaced by the expansion of roads and highways and other measures to reduce infrastructure deficits. Forced evictions constitute gross intrusions on human rights because they indirectly and directly violate the full spectrum of civil, cultural, economic, political, and social rights.

Those who live in settlements on sites that are dangerous and lack risk-reducing infrastructure and services often take measures to reduce risks to their household, homes, and assets. They often work at a community level to collectively address risks – especially in informal settlements or urban centers where there is low government interest or adaptive capacity. Revi et al. (2014) provide a review of these responses, such as maintaining local water sources, toilets, and washing facilities and constructing and improving drainage systems. Such measures can make an important contribution toward risk reduction, especially if they are community-wide responses, but they cannot provide a larger network of infrastructure on which local adaptation measures depend (e.g., water and waste-water treatment plants, and water, sewer, and drainage mains). However, an important lesson of these experiences is that the adaptive capacity and resilience of communities can be sustainably increased by providing appropriate support for community-based initiatives. Support should preferably be provided in the form of economic incentives and opportunities for low- and middle-income households.

6.3 Equity and Climate Change Mitigation

Climate change will affect urban residents not only by climate change-related risks, potential impacts, and adaptation, but also by mitigation actions, policy, and planning. Urban mitigation actions are currently planned and undertaken mostly in cities in high-income countries because these have historically emitted the bulk of GHG emissions, still emit the largest share of urban emissions on a per capita basis, and more often have the means to act. Research on mitigation actions in cities in low- and middle-income countries is currently limited.

6.3.1 Spatial Planning

With respect to spatial planning, cities in low- and most middle-income countries face challenges very different from those in high-income countries (see Chapter 5, Urban Planning and Design). In low- and middle-income countries, spatial planning policies are often outpaced by rapid population growth, whereas city budgets are usually inadequate to meet the ensuing need for expanded or adjusted infrastructure and service provision (UCLG, 2014). Additionally, spatial planning controls are often weak and, where they exist, there is limited enforcement (Bartlett et al., 2009). Particularly in low-income countries, most city governments have not yet begun to plan for climate change. There are only a few cities where climate change mitigation is currently being integrated into city plans (see Hardoy and Ruete [2013] for Rosario; and Roberts [2010], Roberts et al., [2012], and Roberts and O'Donoghue [2013] for Durban).

In cities of high-income countries, mitigation strategies often build on anti-sprawl policies, which attempt to reverse low-density development and encourage urban revitalization. The main principles of this "Smart Growth" planning framework are denser development, walkable neighborhoods, enhancement of mixed land use, and the conservation of open spaces (Wilson et al., 2008). A key objective is to reduce transport and related GHG emissions (see Chapter 13, Urban Transportation). However, these principles are not only praised for reducing traffic, but also criticized for pushing up housing prices and the subsequent displacement of low-income residents unable to afford the higher rents (Addison et al., 2013; Burton, 2000; Cox, 2008; Ewing et al., 2014; Smyth, 1996; Wendell, 2011). In particular, low-carbon building and construction standards, driven by a narrow technocratic vision of climate change mitigation, may undermine socially progressive housing policy and result in housing designs that are unaffordable for low- and medium-income households (Bradshaw et al., 2005; Golubchikov and Deda, 2012). This process is referred to as "environmental gentrification" (Checker, 2011; Curran and Hamilton, 2012; Jennings et al., 2012; Johnson-Gaither, 2011; Todes, 2012). Densification has also been linked to unequal distribution of domestic living space (Burton, 2000) and increases in residents' exposure to air pollutants, particularly if compactness is not accompanied by improved public transportation (Schindler and Caruso, 2014).

Compact city policies may also unequally curtail access to public facilities as well as open and green space thereby exacerbating already existing inequalities (Burton, 2000; Dempsey et al., 2012; Newman, 1972). Access to urban green space often negatively correlates with the racial/ethnic and socioeconomic characteristics of a neighborhood (Dai, 2011; Joassart-Marcelli, 2010; Joassart-Marcelli et al., 2011). In the United States, low-income households in Hispanic, African-American, and Asian communities have less green space within their neighborhoods than city averages (Byrne et al., 2009; Dai, 2011; Landry and Chakraborty, 2009; Sister et al., 2010; Wolch et al., 2014). Similarly, in South Africa, communities of black, low-income residents have sharply reduced access to public green space, as compared with predominantly white residential areas (McConnachie and Shackleton, 2010). Urban mitigation policies aiming at densification need to explicitly focus on an equitable increase in urban density and the distribution of opportunities and benefits of improved environments.

There is no consensus on how fiscal anti-sprawl policies shift burdens on residents with different income levels (Burton, 2000; Sharpe, 1982; Smyth, 1996). However, development taxes imposed to cover infrastructure-related costs seem to imply a lower burden on low-income groups than other instruments such as zoning and growth management policies that mandate which areas can be developed and under which conditions (Bento et al., 2011, 2006; Brueckner, 1997).

6.3.2 Accessibility and Transport Policies

Infrastructure investments aiming at improving public and private transportation services are a frequent and successful means to address climate change mitigation in urban areas (see Chapter 13, Urban Transportation). However, if implemented incautiously investments can potentially impact lower-income households by way of changes of housing affordability, costs of transportation, and accessibility. This is also the case for some policies whose main goal is not mitigation – for instance, policies to restrict private car use or improve public transport to lessen congestion or lower air pollution.

One strategy with the potential to mitigate climate change in cities is transit-oriented development (TOD), i.e., the improvement of access to public transportation (see Chapter 13, Urban Transportation). In addition to its mitigation potential, TOD has positive socioeconomic effects for residents because it brings a larger area of land into the employment catchment area. For example, in Medellin, the implementation of a cable car connected isolated low-income communities with the urban center and contributed to the enhancement of economic conditions and the reduction of violence (Brand and Dávila, 2011; Cerdá et al., 2012). However, studies have also shown that TOD can have negative effects on low-income groups because it influences the level of housing affordability (Deng and Nelson, 2010, 2011; Zhang and Wang, 2013; Smith and Gihring, 2006). In an open housing market, better access to transportation usually leads to

Case Study 6.3 Growth Control, Climate Risk Management, and Urban Equity: The Social Pitfalls of the Green Belt in Medellín

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Keywords	Adaptation, resilience, disaster risk management, growth containment, socio-spatial justice, greenbelt, green infrastructure, resettlement, intense precipitation, heavy downpours, flood, landslides
Population (Metropolitan Region)	3,731,000 (Alcaldía de Medellín, 2015)
Area (Metropolitan Region)	1,152 km² (Alcaldía de Medellín, 2015)
Income per capita	US$13,910 (World Bank, 2017)
Climate zone	Am – Tropical, monsoon (Peel et al., 2007)

For the past fifteen years, the city of Medellín has been actively working on rebranding itself, changing its image of violent crime and drug trafficking to a more welcoming and safer place, better in tune with its environment. Thanks to many social urbanism and "urban acupuncture" projects targeting the urban poor and to the construction of new infrastructure, Medellín received the award for "Most Innovative City of the World" by the Urban Land Institute in 2013.

Announced in 2012, the future Metropolitan Green Belt (73 km, US$249 million) is part of this process of urban reinvention and urban resilience. Conceived as a planning strategy to consolidate the metropolitan territory in a balanced and equitable way, the greenbelt is meant to restrain unregulated growth[4] and sprawl in the hillsides around the city, protect water basins and forests key to the region's biodiversity and to climate control, and, most importantly, reduce risks of landslides during extreme weather events (Agudelo Patino, 2013). Risks of climate disasters exist in Medellín because of a prolonged rainy season with a high prevalence of torrential downfalls and an increase in frequency of extreme rainfall events. Experts predict that extended dry periods will make the unstable soil along the steep slopes even more treacherous, while intense rainfall will increase the incidence of landslides. Today, 180,000 households are located on hillsides and ravines that are at risk of mudslides and other climate-related disasters.

Case Study 6.3 Figure 1 *The Medellín Green Belt.*

Photo: Municipality of Medellín

4 From 1955 to 2013, the population of Medellín almost tripled from 500,000 to 3 million residents, a growth driven by industrialization and internal displacement from armed conflicts.

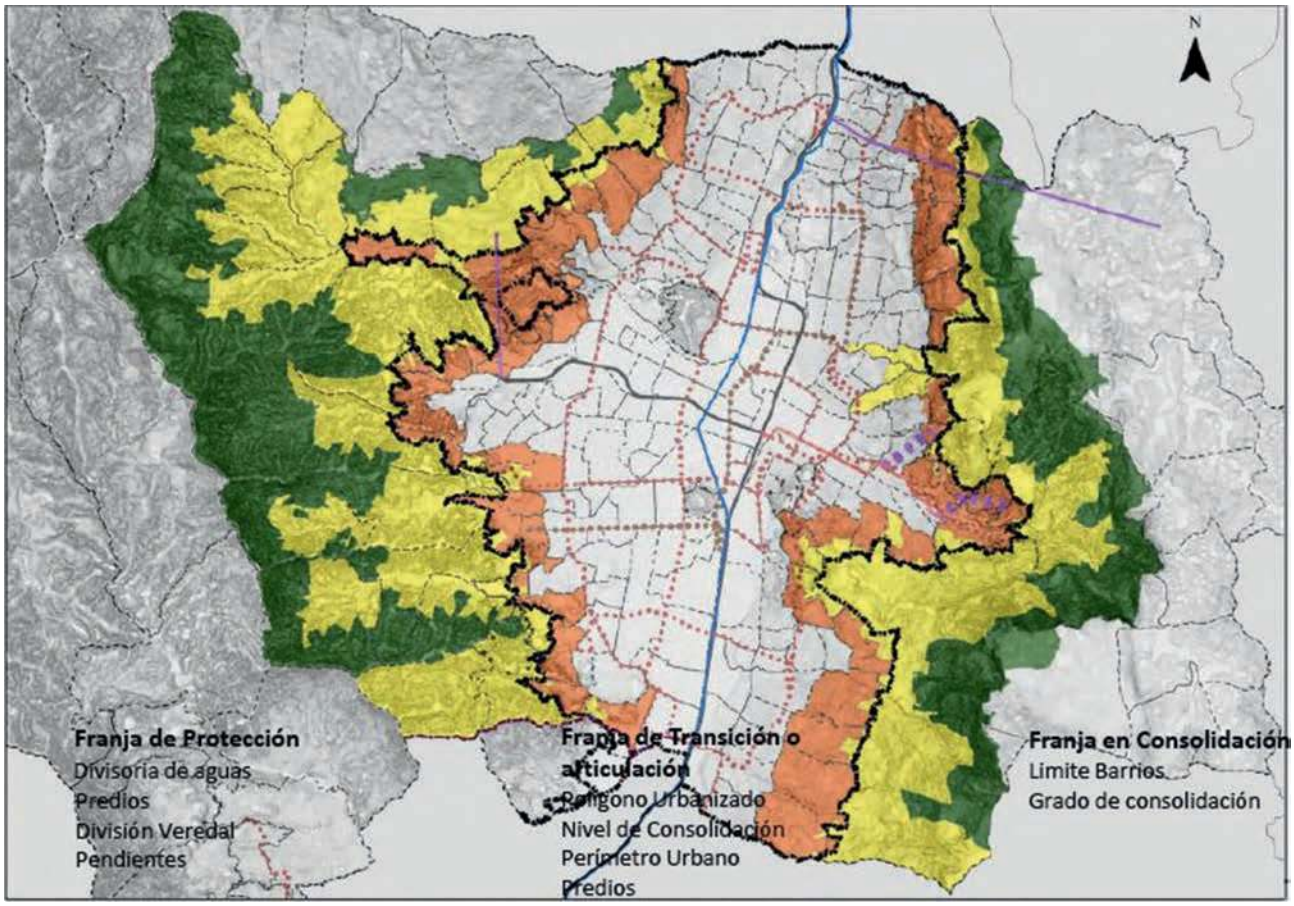
The greenbelt is based on three levels of intervention and will affect 230,000 residents (see Case Study 6.3 Figure 1) who live above the 1,800 meter altitude set by the project, not all of which are considered "high-risk." The first level is a Protection Zone (in green) that is the "Green Belt" itself with natural habitat preservation, ecological restoration of hillsides, recuperation of rural corridors, natural and community tourism, carbon sinks protection, and rural habitat improvement. The second level is a Transition Zone (in yellow), close to the greenbelt, with the highest concentration of residents living in conditions that often lack basic amenities and that have expanded beyond the city limits. This Transition Zone will receive new metropolitan parks, farming projects, education gardens, bike paths, and risk mitigation measures (see Case Study 6.3 Figures 2 and 3). The third zone is a Consolidation Zone (in orange), meant to "re-conquer the Valley," with the creation of longitudinal parks, the construction of high-rises for new residents, structural intervention and habitat improvement projects, land entitlement, and a network of public services. At the heart of the Green Belt, the municipality is also planning a Clean Mobility Corridor (Alcaldía de Medellín, 2013). This project has strong potential to protect the city against more extreme and frequent weather events and to regulate uncontrolled growth on the slopes.

However, the construction of the Green Belt is also raising planning controversies related to sociospatial equity. First, because the municipality is planning to relocate thousands of households living on unstable terrain from the Zone of Transition to the Zone of Consolidation, community concerns have emerged (see Case Study 6.3 Figure 4). Most low-income residents do not want to be relocated and would prefer alternative solutions to risk management (interviews in 2013 and 2015). For instance, in Comuna 8, where the municipality is planning to relocate 6,600 households (but possibly up to 39,200 households), residents are opposed to the idea of being evicted from the houses they built during the armed conflict and being moved into city-built tower blocks far away from their original settlement. Controversies over relocation also highlight the political nature of risk assessments and maps since discrepancies exist between different sources of assessment – the Risk Zone map of the city, the Geological Aptitude Map (a map of geological risks associated with different land types), and resident-produced estimates of the number of households in "non-recoverable risk areas."

Second, decisions over which communities have to move away from the greenbelt highlight spatial inequity in urban development and relocation. Higher-income neighborhoods (El Poblado, Cedro

Case Study 6.3 Figures 2 and 3 *Renderings of the Medellín Green Belt.*

Source: Global Site Plans



Case Study 6.3 Figure 4 *The three zones of the Medellín Green Belt.*

Source: Urban Solutions Platform

Verde, Alto de las Palmas) seem to be able to further expand toward the top of the hills in South East Medellin even though they have expanded beyond the city border. Gated communities such as Alto de Escobero, which is next to important reserves of native forest, are continuing to grow without a mention of their need for resettlement (Arango, 2012). In contrast, the municipality is planning to move residents from lower-income neighborhoods (Comuna 8).

Third, although the future system of longitudinal connectivity and mobility – to be built along with the Green Belt – linking new mobility projects such as bike paths, hiking trails, and a monorail system to the city's current urban transit system will create new environmental benefits for the city's residents, it could bring new forms of environmental privilege. Low-income residents fear that this monorail will attract tourists and wealthier residents benefiting from easier connections to new recreational areas and parks such as Park Arví (Interviews 2013 and 2015). Additionally, the Metrocable and other forms of public transport would stop before the furthest extent of these communities, and there is no plan to improve access to the city for the most vulnerable residents. By the same token, low-income residents would lose access to green space around the Pan de Azúcar Mountain on which they rely for their livelihoods and sources of fresh food. Even though the Pan de Azúcar is farmed by many residents, public officials see it as an important ecological resource to preserve and transform into a recreational area.

Last, low-income residents from communities impacted by the Green Belt are concerned about a lack of meaningful engagement with affected vulnerable communities and a lack of recognition of their land-use and planning experience. In Comuna 8, using the three pillars of social and ecological function of property, direct participation of citizens in decision-making, and equitable distribution of costs and benefits of urbanization from the 1991 Constitution, residents have prepared a community development plan asking for the municipality to articulate the Green Belt project with their Declaration of Needs and Wants, including integral barrio-upgrading projects, food security and urban agriculture, risk management with the construction of proper sewage systems and retention walls, and housing and transportation improvements. Yet, to date, the dialogue between residents and the municipality has not produced tangible results and solutions.

In sum, the Green Belt project reveals that, although green infrastructure offers much resilience and climate adaptation opportunity for cities affected by climate impacts, such efforts may produce accelerated cultural, economic, and physical displacement for the most vulnerable residents while overlooking needs for social cohesion, community recognition, and livelihood protection.

an increase in property values and rents in zones of improved infrastructure services and particularly transportation nodal points. As a result, low-income groups may be forced to migrate to other locations with limited access to transportation but more affordable rents and housing prices (Boarnet, 2007; Deng and Nelson, 2011; Munoz-Raskin, 2010; Zhang and Wang, 2013).

Another aspect of concern with regard to social inequality is the usually high up-front costs required to access discount fares, such as annual or monthly transit passes. Low-income households may be obliged to purchase weekly or daily passes, which can be up to three times more expensive than longer term passes (Nuworsoo et al., 2009; Schweitzer, 2011). Moreover, an increase in the costs of transfers or the removal of unlimited-use passes mostly affects lower-income riders, youth, and minorities because these groups make more trips and transfer more frequently than others (Cheng et al., 2013; Nuworsoo et al., 2009).

Gender-based violence, harassment, and crime in public transport are also sources of concern and should be addressed through gender-sensitive transportation-based mitigation actions. For instance, Montreal, Bogotá, Malmö, Vienna, and Berlin are noteworthy pioneer cities that have mainstreamed gender in their mobility plans. These cities have sought to improve the accessibility, safety, and comfort of public transport and prioritize women's perspectives (Maffii et al., 2014; Levy, 2013; Clarke, 2012).

Transport policies aiming to improve private transportation infrastructure often show contradictory results with regard to their effects on equity mainly due to the range of policy options available (whether these include tax revenue recycling and/or other additional benefits[5]) and the use of different methodologies in defining inequality (Schweitzer, 2011). For example, fuel taxes and vehicle registration fees, although highly dependent on instrument design and the associated revenue recycling measures, generally show very small effects across income groups (Dill et al., 1999; Walls and Hanson, 1999; Fullerton et al., 1980; Bento et al., 2005). However, registration fees that are based on pollutant emission rates typically affect low-income drivers more than those based on distance traveled, because low-income residents drive vehicles that pollute more per mile than do those owned by wealthier groups of the society.

Cordon charges (location- or time-based charging tolls on a road network or upon entering a defined zone) include two main types of pricing strategies: cordon tolls and area charges. The key difference is that the first one tolls travelers per crossing whereas the second one tolls users for a license (i.e., one-day period) to enter or travel inside an area. On average, area-based schemes tend to perform better than crossing schemes in terms of equity effects because, with the same boundary, they affect a higher volume of demands in the network compared to cordon tolls (Maruyama and Sumalee, 2007). However, very specific time-based cordon tolls for peak hours are also progressive. For example, in Stockholm, the relative burden change amounted to 0.35% for low-income groups if revenues were allocated to public transit or tolls were low enough (Eliasson and Mattsson, 2006). Area-based schemes showed a higher burden of more than 2% for low-income motorists (in the case of Paris), but this changes to 0.5% when all commuters are factored in (Bureau and Glachant, 2008). Overall, cordon charges can produce beneficial outcomes to low-income households by reducing traffic congestion and improving air quality when considering social and environmental benefits and/or revenue recycling (Creutzig and He, 2009; Schweitzer, 2011; Creutzig et al., 2012).

Speed limit schemes can cause burden changes from 5% to 17%, depending on the integration (or not) of commuting patterns in the policy design (Schweitzer, 2011; Wang, 2013). Finally, in terms of environmental inequity, charges based on road usage seems more effective than those based on low emission zones (LEZs)[6] because the latter might cause an increase in emissions in the surrounding areas – with potential effects on lower-income communities. Moreover, the quality benefits sought by LEZs may also occur in a do-nothing scenario due to fleet renewal processes (Carslaw and Beevers, 2002; Mitchell, 2005).

Overall, both urban geography and individual characteristics of policies determine who benefits from spatial planning and transport mitigation strategies (Santos and Rojey, 2004). Mitigation strategies may only exacerbate inequalities if the design and implementation does not take into account differential impacts on low-income and other vulnerable groups. Distributional impacts are city-specific and require a case-specific evaluation on multiple scales, such as the travel behavior of different communities.

More generally, there is the issue of where responsibility for decarbonization in transport systems is located and the worry that neo-liberal mechanisms will exacerbate inequalities in travel patterns (Schwanen et al., 2011). Hence, policy-makers should try to anticipate negative effects and offset them by adopting additional measures or modifying policy designs. Dulal et al. (2011) note that, in the context of urban growth, ensuring that all neighborhoods in an urban settlement are equally served by efficient public transport routes can be effective not only in reducing transport volumes and private vehicle use, but also in lessening distributional and welfare inequality of GHG emissions reduction (Grazi and van den Bergh, 2008).

6.3.3 Waste Management and Renewable Energy

Sector-specific policies for urban waste management have not yet been explicitly analyzed in terms of equity performance, although some studies offer insights on specific issues, for example waste-pickers. Waste-picking constitutes the major reuse and recycling business in urban centers in many low- and

5 Revenue "recycling": Use of tax revenues to lower other taxes or to finance explicit public investments. Additional benefits include environmental benefits (i.e., lowering pollution) and social benefits (i.e., lowering time congestion).

6 Low emission zones (LEZs): An air quality management tool in which most polluting vehicles are barred from a specific area.

middle-income countries, thereby helping to avoid substantial GHG emissions (King and Gutberlet, 2013). One study in Ribeirão Pires, Brazil showed that the informal/cooperative recycling sector was capable of achieving GHG emissions reductions similar to those in formal solid waste management, recycling, and landfill gas capture (King and Gutberlet, 2013). Although being sustainable, inclusive, and integrated, it is a survival strategy that sometimes faces strong opposition from authorities (Hunt, 1996 Hayami et al., 2006; Chen et al., 2013). When improved waste collection and management becomes a public priority, pickers are often displaced and become unrecognized (Rouse and Ali, 2001; Ahmed and Ali, 2004; Scheinberg and Anschütz, 2006; Wilson et al., 2006; Medina, 2008; Betancourt, 2010), regardless of their environmental contribution and the subsequent social impacts (Huysman, 1994; Baud et al., 2001; Moreno-Sánchez and Maldonado, 2006). However, some progressive cities have devised contractual arrangements for waste-pickers (Fergutz et al., 2011; Kareem and Lwasa, 2011; Vergara and Tchobanoglous, 2012; Campos and Zapata, 2013). Pro-poor recycling strategies like those in Maputo and Bangalore have strengthened waste-pickers' cooperatives through improvements in infrastructure, governance, and skills, thereby obtaining benefits in a number of sustainability dimensions (Storey et al., 2013).

Renewable energy schemes may also lead to unequal burden shifts because low-income households often contribute a larger fraction of their income to such schemes than do higher-income households. This reflects a fundamental bias of incentive-based mechanisms that leave high-income households following their old consumption practices (and paying a bit more) while leaving low-income households scrambling to adjust (Earl and Wakeley, 2009; Perry et al., 2013).

6.4 Innovations and Lessons from Implementation

A growing number of city governments have made innovations in climate change adaptation and mitigation. These include many cases where cities have taken action despite the lack of supporting national policies and international funding (Reckien et al., 2014; Bulkeley and Castán Broto, 2013), including in low- and middle-income nations (Bicknell et al., 2009; Anguelovski and Carmin, 2011; Bulkeley and Castán Broto, 2013; Castán Broto and Bulkeley, 2013; Carmin and Dodman, 2013). Recently, more attention has also been given to adaptation, but few policies explicitly address the risks of low-income groups, especially the billion urban residents in informal settlements (Satterthwaite and Mitlin, 2014).

Policy programs tend to distribute benefits and costs along existing social class lines and thereby often overlook the exclusion of low-income people and other economic, social, or ethnically underrepresented groups – who often live in informal settlements – from the environmental policy process (Pelling, 1998; de Sherbinin et al., 2007). This is evident in housing, infrastructure, and disaster risk reduction programs. The exclusion leads to an underrepresentation of the needs of these groups in formal environmental policies and a failure to recognize the value of "autonomous adaptation" initiatives (Huq et al., 2007; Bartlett et al., 2009). Thus, these groups often receive little support from formal governance processes (Roy et al., 2012).

Urban community actors – often elite groups and/or commercial enterprises based in the community – may fill the vacuum of formal governance systems by establishing their own informal rights for the settlers and by acting as intermediaries between the settlers and wider urban institutions (Khan, 2000). Informal governance structures can transform slums into areas of innovation, developing the social capital and cohesiveness required for adaptation to climate change (Pelling, 1998; Khan, 2000). For example, in the Dharavi section of Mumbai, inventers and innovators at the household level have transformed the slum through waste economies, installation of infrastructure, negotiations for land rights, and the mobilization of people in the wider community (Appadurai, 2000; 2001). Such measures help secure collective survival and enable people to adapt to climate change through social bonding and the sharing of costs and benefits. However, informality can also make it more difficult to manage uncertain or unpredictable hazards created by climate extremes.

Moreover, informal governance may also be conducive to crime and give rise to poorly integrated social structures (Galea and Vlahov, 2005; Roy et al., 2012). Poor and underrepresented groups often become the victims of injustice created by informal institutions – in a way similar to those produced by formal governments – and their structural (re)arrangements. In cities such as Mumbai, Nairobi, Lagos, Delhi, Manila, and Dhaka, access to water, sanitation, other services, and infrastructure is often controlled by commercial enterprises, elites, or other influential community actors (Khan, 2000; Akanda and Hossain, 2012; Cullis et al., 2011; Roy et al., 2012). These informal governance regimes are a response to lack of formal provisions of services to informal settlements often based on discrimination due to race, caste, class, and gender (Cullis et al., 2011; Akanda and Hossain, 2012). It is the goal of many environmental and social justice institutions and policy programs to break this exploitative cycle (Franzen and Vogl, 2013; Deneulin, 2014; Rakodi, 2014).

There is an increasingly greater recognition of the importance of city governments in both adaptation and mitigation and of the need for city governments to align their agendas for development, poverty reduction, and disaster risk reduction with adaptation and mitigation (see Chapter 1, Pathways to Urban Transformation). A review of disaster risk reduction actions of more than fifty cities within the United Nations International Strategy for Disaster Reduction (UNISDR) "Making My City Resilient" campaign shows how resilience to disasters is being conceived and addressed by city governments, especially with regard to changes in their institutional frameworks

and engagement with communities (Roy et al., 2012; Johnson and Blackburn, 2014) (see Chapter 3, Disasters and Risk). This commitment is also expressed in efforts to mobilize finance, undertake multi-hazard risk assessments, upgrade informal settlements, adjust urban planning procedures, and implement building codes. Many cities report paying particular attention to vulnerable groups and encourage them to actively participate in risk reduction decision-making, policy-making, planning, and implementation (Johnson and Blackburn, 2014).

These initiatives demonstrate the potential overlap between building resilience to climate change and poverty reduction. Cities in low- and middle-income nations that have taken action to upgrade informal settlements and expand provision of infrastructure and services have thereby helped to reduce the risk differentials between neighborhoods and residents. Thus, these measures can also be labeled as climate change adaptation because they help build resilience to climate change impacts.

However, adaptation investments may also prioritize the protection of the formal city infrastructure and ignore informal settlements (Roy et al., 2012). City governments in low-income (but sometimes also in high-income) countries often bulldoze informal settlements to make room for infrastructure "improvements" that serve central districts and middle- and upper-income groups (Macharia, 1992; Collins and Shester, 2011). Another example of urban activities that have gone against the needs of the most vulnerable is the filling up of natural water bodies to make way for construction or their conversion to economic uses. This can have consequences for traditional drainage systems and lead to an increase of waterlogging and the frequency or severity of floods (Tanner et al., 2009). Research in Bangladesh and Vietnam has investigated climate impacts and adaptation options in Satkhira and Hue, respectively (McEvoy et al., 2014). In both cases, local human intervention is undoubtedly having an influence on flooding and waterlogging. Important equity issues are raised in instances that have downstream consequences for the most vulnerable in society. However, the opposite can also be observed (i.e., the poor may encroach on traditional water bodies through landfill, narrowing river beds, and causing water areas to shrink, thereby contributing to increased flooding risk that may affect wider urban areas).

Most cities are affected by local political constraints and powerful vested interests that may oppose equity-sensitive adaptation and mitigation, especially if this restricts the land available for development or imposes measures and standards that may limit profits. Cross-municipal and cross-departmental action in urban agglomerations also faces governance challenges. For example, the Asian Cities Climate Change Resilience Network (ACCCRN) has faced challenges in sharing learning among different interest groups in politicized urban environments. However, the engagement and support of all relevant sectoral departments are needed for implementation (Roberts, 2010; Roberts et al., 2012). Several cities have therefore created a climate change focal point to help coordinate climate action across government departments or agencies (Roberts, 2008; Roberts, 2010; Anguelovski and Carmin, 2011; Hunt and Watkiss, 2011; Brown et al., 2012). However, locating it in the environment department may not ensure sufficient attention because environment departments are typically weak, with limited budgets and influence, as in Durban (Roberts, 2008; Roberts, 2010), Boston (City of Boston, 2011), and Sydney (Measham et al., 2011). In contrast, New York's climate change adaptation agenda is guided by a Climate Change Adaptation Taskforce anchored within the Mayor's Long-Term Planning and Sustainability Office (Rosenzweig et al., 2010; Solecki, 2012). The Taskforce includes various city and state agencies and private companies involved in critical infrastructure, and it is advised by the New York City Panel on Climate Change.

Providing a space for discussion of vulnerability and resilience in each city's particular context is essential (Roy et al., 2012; Reed et al., 2013). Budgetary transparency and metrics to measure progress on adaptation and mitigation can also help to institutionalize changes in planning and policy practice (OECD, 2012). There still is very limited documentation of the design and implementation of climate change adaptation initiatives and its monitoring, particularly in cities in low-income and many lower-middle-income countries, but household and community-based adaptation, both its importance and limitations, has been a main focus (Moser and Satterthwaite, 2008; Carcellar et al., 2011; UN-Habitat, 2011; Dodman and Mitlin, 2013; Wamsler and Brink, 2014). A number of capacity-building initiatives have been developed, such as the Urban Climate Change Research Network (Rosenzweig et al., 2011) to address these shortcomings. However, additional targeted support is needed to secure the engagement of smaller cities in climate change efforts (Reckien et al., 2014) and to include guidance and training for city staff (Moser, 2006; Carmin et al., 2013; Tavares and Santos, 2013), particularly with respect to the full range of equity concerns that are characteristic of cities.

City and municipal governments need support from multi-level governance frameworks through which provincial and national governments enable and support city and municipal action (Corfee-Morlot et al., 2009; Revi et al., 2014) (see Chapter 16, Governance and Policy). Some national governments have developed new laws, funds, and regulatory frameworks to channel such support; many of these are focused on disaster risk reduction (Hardoy and Pandiella, 2009; IFRC, 2010; Carcellar et al., 2011; Kehew et al., 2012) and on increasing the resilience of the most vulnerable groups. However, in some countries, current policies, especially at the federal level, have major negative consequences for low-income and ethnic communities. Urban equity policies therefore cannot fully address the "root of the problems" and will struggle to achieve justice if the institutions that are creating policy – higher-level, national and international policy environments – fail to engage with equity and environmental justice efforts. WE ACT, a local environmental justice organization in the United States, specifically tries to address environmental injustices that are caused by national (climate change) policies.[7]

7 www.weact.org

Case Study 6.4 Individual, Communal, and Institutional Responses to Climate Change by Low-Income Households in Khulna, Bangladesh

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Keywords	Poverty, flood, resilience, household adaptation, community-based adaptation, institutional adaptation, environmental justice
Population (Metropolitan Region)	759,618 (BBS, 2013)
Area (Metropolitan Region)	72.6 km² (BBS, 2013)
Income per capita	US$1,330 (World Bank, 2017)
Climate zone	Aw – Tropical savannah (Peel et al., 2007)

Khulna is the third largest metropolitan city in Bangladesh, located in the coastal region in the southwest of the country (see Case Study 6.4 Figure 1). Climate-related hazards have long been experienced in and around Khulna, for instance, floods, storms, limited availability of fresh water, waterlogging, and heat waves. This study examines the underlying drivers of vulnerability as they affect extremely low-income residents of the city. In addition, it examines the potential for actions taken at the household and community levels in urban areas to go beyond offering short-term "coping" solutions in response to specific events and instead result in more transformational changes that address the underlying drivers of vulnerability.

Other than the conventional "socioeconomic" and "biophysical" vulnerability, this research identifies a third type of vulnerability in the study area, which can be termed "legal vulnerability" and is derived from the tenure insecurity of the low-income urban residents. Tenure insecurity is a major factor dissuading low-income households from investing in their housing to make it more adaptive to climatic shocks because they live in constant fear of eviction. A wide range of specific adaptation-related activities can be identified as responding to these vulnerabilities, and these can be grouped into three main categories: individual, communal, and institutional. The study examines the extent to which institutional actions meant to address these underlying vulnerabilities are merely coping or whether they create the conditions in which individuals and households can strengthen their own long-term resilience. Similarly, it examines the extent to which individual and communal responses are coping or whether they have the potential to generate broader political change that strengthens the position of marginalized groups in the city.

ADAPTATION PRACTICES: HOUSEHOLD, COMMUNAL, AND INSTITUTIONAL

Low-income residents in Khulna are already taking a wide range of actions to respond to climate-related hazards (see Case Study 6.4 Figure 2). These are largely spontaneous or "impact minimizing" rather than planned or "preventative," often because residents lack the means to make more substantial changes. They are also ingenious and varied, particularly recognizing the severe technical, locational, and economic constraints under which these households operate.

Most of these actions involve making modifications to the physical dwelling and its immediate surroundings to deal with different types of threats (see Figure 2A). Many of these deal with hazards related to heavy rainfall and flooding. Polythene sheets or the covers from cement bags are placed on the roof and in wall openings as protection from heavy rain. Plinths are elevated or houses are built on stilts to avoid waterlogging. If flooding does take place, household goods are placed on shelves near the ceiling, and furniture is lifted off the floor using bricks or wood. In addition, a wide range of approaches using locally available materials, such as *golpata* (Nypa leaves), are used to repair damaged houses. Residents also use community kitchens during disasters to reduce costs. As part of climate-proofing or recovery from extreme weather events, communal activities involve building or repairing common services (i.e., tube wells, drains, toilets, elevated pathways, and small retaining walls at the edge of water bodies to prevent land erosion).

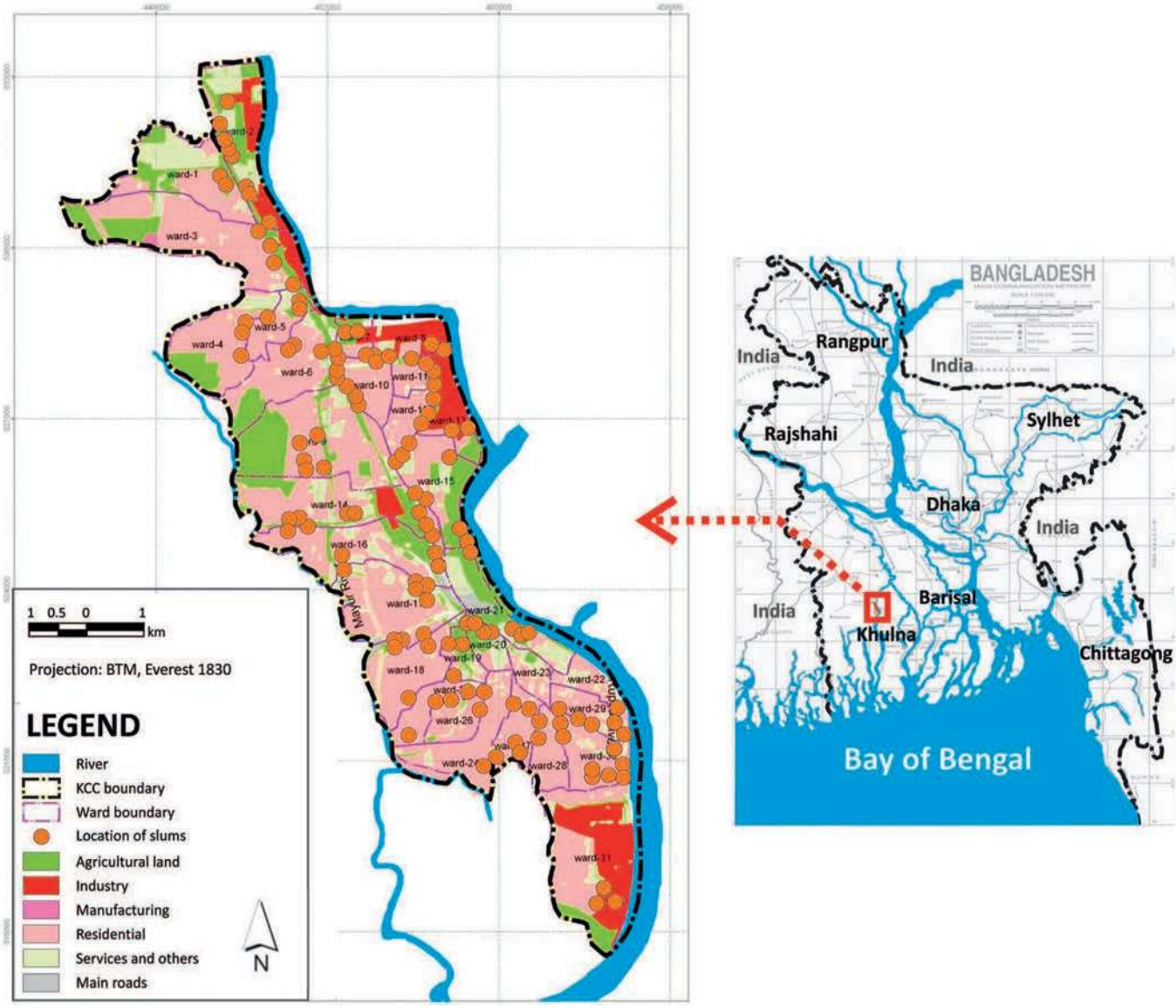
A considerable number of institutions operate in these areas, both public (City Corporation) and private (nongovernmental organizations [NGOs] like Save the Children, Bangladesh Rural Advancement Committee [BRAC], Water Aid). The City Corporation is mostly engaged with post-disaster relief. The NGOs work more generally on community development as well as on providing emergency services during disasters.

TOWARD TRANSFORMATIONAL CHANGE THAT REDUCES VULNERABILITY

None of the existing responses addresses the underlying social and political marginalization of the communities, which is perhaps the single most important feature contributing to their vulnerability to climate variability and change. While all the inhabitants of the city are entitled to basic service provision, the City Corporation in Khulna fails to acknowledge the existence of many informal settlements. This means that they are excluded from the City Corporation's provision of basic services. Improved provision of basic services and infrastructure would be a considerable contribution to vulnerability reduction by strengthening the adaptive capacity of individuals and households and by reducing exposure to flooding and waterlogging. In turn, such public investment could increase the motivation of residents to invest in improvements.

Another significant underlying factor contributing to vulnerability is the position of these low-income and informal settlements, most of which are in locations categorized as low-lying or agricultural rather than residential because areas designated for residential use are unaffordable to the very poor. Some of these are in areas that are exposed to particular hazards. Although responses to informality have gradually recognized the advantages of *in situ* upgrading (as opposed to relocating), the changing risk context as a consequence of climate change may result in the acceptance of the need to move some residents. However, this requires strong relationships of trust between organized community groups and local authorities.

One possible response to risk is to use the skills and knowledge that already exist in these communities. These skills and knowledge are

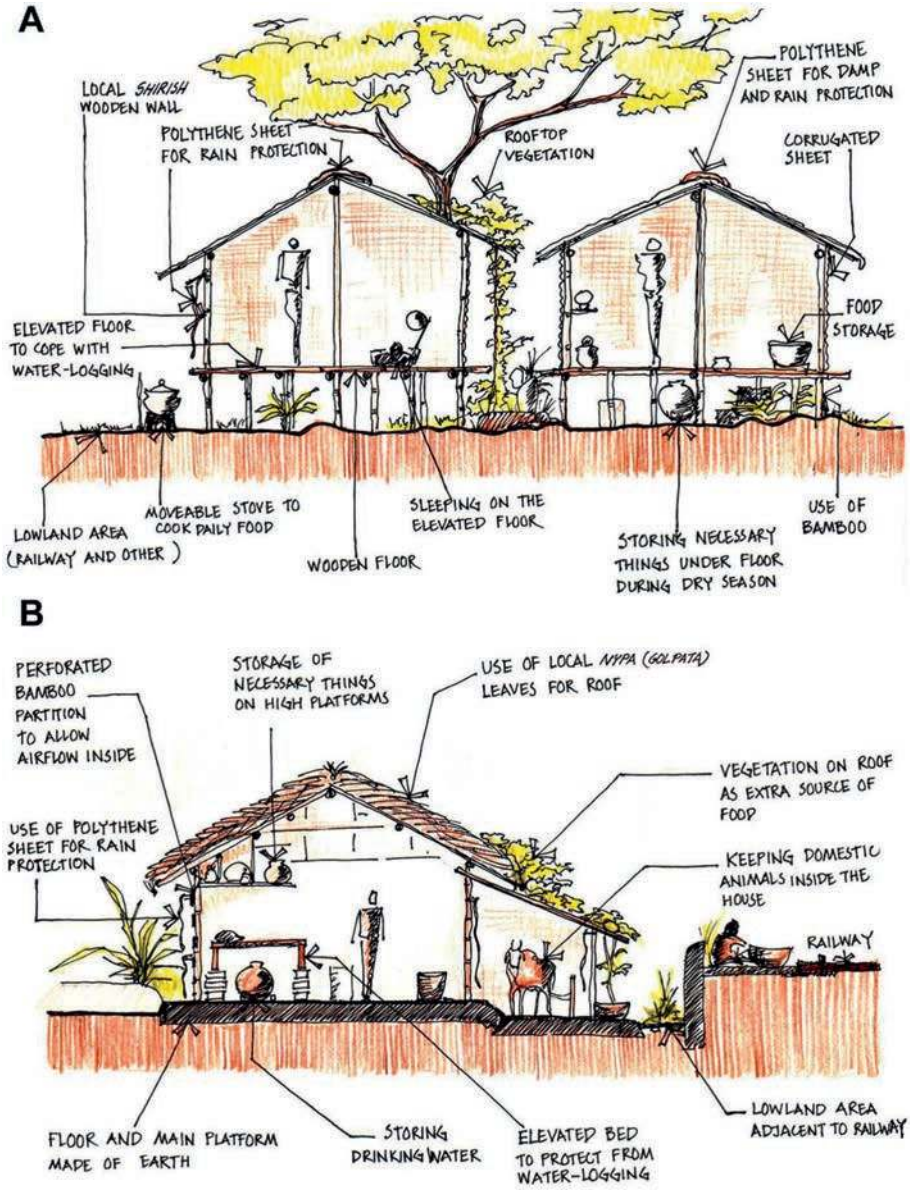


Case Study 6.4 Figure 1 *Location map of the city of Khulna (showing land use and low-income settlements).*

more likely to be used by residents if they are more confident that their efforts will not be lost through forced evictions. Their knowledge can be supplemented through awareness-raising and training workshops that can also help to prevent maladaptation. For example, although elevating the level of paths and walkways may reduce flooding in one location, if this is done without adequate consideration for broader drainage patterns it can worsen the issue elsewhere.

Another response that strengthens the adaptive capacity of low-income communities is to support the development of climate-resilient livelihood strategies. People living in low-income areas of Khulna have already been identified as undertaking different ways of earning money, and these have often been supported by NGOs – for example, through providing financial services (assets or capital) to develop small businesses such as sewing, handicraft production, and retail outlets. Households with savings have greater coping ability during a crisis (Dodman et al., 2010), and the city corporation and NGOs are implementing different types of saving schemes. NGOs have also been seeking to strengthen women's access to and control over assets and resources, thereby boosting the ability to make decisions, participate in the process of city governance, and thereby strengthen their resilience. However, efforts also need to be made to improve information-sharing about climate-related risks. Because the majority of the households surveyed do not have televisions, radios, or mobile phones, they lack access to climate change information from media sources and are therefore unable to take actions to reduce the consequences of particular climate-related events, in addition to being uninformed of longer-term climate trends. Although the City Corporation provides public service announcements using loudspeakers, this is only delivered to riverbank settlements.

All of these issues will require greater engagement and accountability from institutional actors. The Khulna Development Authority is responsible for enforcing regulations (which are also monitored by the Khulna City Corporation) to ensure that landlords meet the minimum standards of housing infrastructure, while the presence of active NGOs can also reduce the likelihood of forced evictions. These responses can provide an incentive to low-income residents to invest in their housing, make physical adjustments to their shelter, and sometimes even improve the settlement to better adapt to climatic variability and change.



Case Study 6.4 Figure 2 *Household adaptation to climatic changes – modifications to household structure to reduce impacts of climatic events.*

The experiences of these residents of Khulna indicate that many activities are already being taken that respond to particular threats. However, while these short-term practices may respond to urgent needs, they will be insufficient in the longer term. Long-term meaningful resilience is not possible without institutional support to households and communities – and this in turn will not happen unless households and communities have effective ways of influencing the processes of urban governance. Equally, this needs to be supported by national policies that grant responsibility, autonomy, and resources to local authorities to address local and urban development concerns. National, urban, institutional, communal, household, and individual adaptation are therefore all required to achieve meaningful and enduring resilience.

More effective international, national, and municipal financing mechanisms that are able to channel resources toward local projects, particularly those that help the poorest and most vulnerable groups to adapt to climate change, are also needed (Smith et al., 2014a) (see Chapter 7, Economics, Finance, and the Private Sector). In this respect, the municipal government is a duty bearer for financial support. For example, the Kuyasa Fund in Cape Town, South Africa, provides microfinance lending for housing, targeting the most vulnerable groups, particularly women. The funds are frequently used to finish external house walls to increase space and improve thermal efficiency (Houston, 2010). This fund could, in the future, be redesigned to encourage additional retrofitting, ideally combined with energy-saving measures (Mills, 2007; UN-Habitat, 2008b; Alber, 2011).

Overall, to secure fairness and sustainability in climate change actions, the combined further development of the formal institutional, regulatory, financial, economic, and social frameworks is paramount (Satterthwaite, 2013). Women in particular should be recognized as important agents of change; they create solutions

Case Study 6.5 Public-Private-People Partnerships for Climate Compatible Development in Maputo, Mozambique

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Keywords	Flood, participatory methodologies, partnerships, climate compatible development, environmental justice
Population (Metropolitan Region)	2,655,000 (Demographia, 2016)
Area (Metropolitan Region)	414 km^2 (Demographia, 2016)
Income per capita	US$480 (World Bank, 2017)
Climate zone	Aw – Tropical Savannah (Peel et al., 2007)

Mozambique is highly vulnerable to natural disasters, particularly those of hydro-meteorological origin such as floods, drought, and cyclones. In Maputo, the capital city with about 1.2 million inhabitants, the main hazards associated with climate change are likely to be temperature increase, extreme precipitation events, and sea level rise leading to increased flood risk in low-lying areas (Maputo Municipal Council et al., 2012).

Climate change in Maputo must be understood in the context of vulnerability linked to poverty and deficient infrastructure (Castán Broto et al., 2013). Approximately 54% of residents live below the poverty line of US$1.50 per day, and 70% live in dense, unplanned neighborhoods with deficient water supplies, sanitation, and drainage (Maputo Municipal Council et al., 2012). Many of these neighborhoods occupy low-lying areas.

The climate project Public-Private-People Partnerships for Climate Compatible Development (4PCCD) ran from 2011 to 2013 and aimed to empower people living in Maputo's poor neighborhoods, to design and implement activities to adapt to climate change.[8] Among others, the project worked in the neighborhood of "Chamanculo-C," where the municipality was preparing an upgrading program.

4PCCD was funded by the Climate Development Knowledge Network and conceived collaboratively by the Mozambican government's Environment Fund (FUNAB) and a group of UK academics led by the Bartlett Development Planning Unit, University College London. Although it was initially interested in climate change mitigation, recurrent flooding in neighborhoods such as Chamanculo necessarily oriented the project toward adaptation (Case Study 6.5 Figure 1).

Case Study 6.5 Figure 1 *Flooding in Chamanculo-C Neighborhood, Maputo.*

8 http://www.bartlett.ucl.ac.uk/dpu/4pccd

Case Study 6.5 Figure 2 *Residents group meeting, Chamanculo-C Neighborhood, Maputo.*

The project involved three stages: (1) a review of studies on climate change in Maputo to characterize key impacts and identify vulnerabilities (January to December 2012); (2) the implementation of a participatory methodology in a specific neighborhood in order to share climate change information, identify potential impacts, and develop potential solutions (mainly from January to June 2013, but continuing into 2014); and (3) the presentation of the community's proposals to a wide range of municipal and national institutions to establish partnerships for implementation (May to July 2013) in order to make explicit the knowledge and priorities of the communities.

The project used participatory action plan development (PAPD), a consensus-building tool that seeks to identify and solve environmental problems with community support and input through different participatory techniques and principles, such as the recognition of the wide range of stakeholders and of their diverse interests and their full engagement (Castán Broto et al., 2015). Using this methodology, the driver of action was the community, represented by the Climate Planning Committee (CPC).

In Chamanculo-C, five groups identified at the start of the PAPD exercise by the community (elderly, young people, traders, employees, and housewives) analyzed the causes and impacts of flooding and potential future impacts and solutions (Case Study 6.5 Figure 2). Existing impacts, including loss of access, damage to property, and vector-borne diseases, are keenly felt by residents, and vulnerability to climate change impacts became a focal point for discussion. The groups elected the CPC which, with facilitation, compiled the community's proposals into a Community Plan for Climate Change Adaptation and presented it at a multi-stakeholder workshop to seek support. Proposals included improving drainage and waste management through community organization, development of a recycling center, repairing water supply networks, and community-led environmental education.

Actor-mapping was used to understand the key players who were delivering climate change interventions in Maputo and who might become partners in the project. This led to the involvement of other key stakeholders, including municipal departments, Eduardo Mondlane University, UN-Habitat, neighborhood leaders, and civil society organizations working in Chamanculo-C. Following presentation of the Community Plan, the project enrolled other actors suggested by the CPC: local businesses, the Mozambican recycling association, the water utility, and the Ministry for Environmental Coordination.

IMPACT AND SCALE

The project worked directly with a small community of one administrative block *(quarteirão),* containing 82 households with 570 members. However, the CPC also worked with the leaders of neighboring blocks, and the Community Plan included proposals relevant to the whole of Chamanculo-C, with a population of about 26,000. Given its experimental character, this project could not have been implemented at a larger scale without a prior proof of concept – which 4PCCD has now provided.

The PAPD process strengthened community organization and representation through the establishment of the CPC, whose expertise and legitimacy have been acknowledged by stakeholders and policy-makers. Now, some months after the initial project, the residents are mobilizing external funding and moving toward implementation of their proposals.

The project team is positive about the long-term viability of the outcomes. The CPC put forward feasible proposals, including community organization to clean and maintain the drainage channel, a community waste separation and composting center, and community-led environmental education. Key institutions including FUNAB and Maputo Municipality have expressed commitment to their implementation. There is no evidence of policy impact yet, but, following the project, the municipality has embarked on deeper climate change planning processes.

LESSONS LEARNED

4PCCD demonstrated that, in Maputo, local communities are capable of organizing themselves for collective action; engaging with climate information, uncertainties, and future scenarios when these relate to their daily experiences; and developing and presenting sensible proposals that directly tackle climate change vulnerabilities. Communities have a grounded understanding of climate change and can do a lot with limited resources by drawing on their own human capital. The project also demonstrates that government institutions and businesses have much to gain from listening to local perspectives.

In Maputo, the participatory process has been a means to build and share an understanding of the challenges for communities faced by climate change. Longer timeframes are nonetheless required to show whether the community's ideas are practicable.

to environmental problems and alleviate GHG emissions in their daily activities. For example, the ninety women heads of households belonging to the women's group Guardianas de la Ladera (Guardians of the Hillside) in Manizales, Colombia, carried out traditionally male work in order to preserve their houses and the environment on unstable city hillsides (UNDP, 2009). Another project called Girls in Risk Reduction Leadership in Ikageng, a township of Potchefstroom, South Africa, aims to reduce the social vulnerability of underrepresented adolescent girls using practical capacity-building initiatives. Girls were trained by experts in areas such as personal and public health, fire safety, counseling, and disaster planning. Girls can help design risk reduction plans for the community to improve resilience (UNISDR et al., 2009).

6.5 Equity Impact Assessments in Cities

To ensure that formal and informal adaptation and mitigation policies and programs do not have detrimental effects on urban equity, recent international reviews propose carrying out structural equity impact assessments (Kallbekken et al., 2014). The aim is to support the equitable and sustainable implementation of environmental and climate change policies, similar to the environmental impact assessments that are applied ahead of major infrastructural investments in many countries.

Four assessment approaches are currently discussed in the literature: (1) the Equity Reference Framework (ERF) (CAN Equity Group, 2014), (2) an open indicator approach, (3) the template of indicators approach (Kallbekken et al., 2014), and (4) the equity framework of McDermott et al. (2011):

1. The ERF was suggested by the Climate Action Network (CAN Equity Group, 2014) as a way to operationalize common but differentiated responsibilities in international climate negotiations. In this respect, its usefulness has been questioned (Kallbekken et al., 2014). A key concern is that local equity may be undermined or existing inequalities exacerbated when nationally and globally aggregated or uniform indicators are used without considering local circumstances (McDermott et al., 2011). Another point of contention is the differential treatment of adaptation and mitigation; the latter is substitutable, whereas adaptation is assumed to be largely place-specific. UN Framework Convention on Climate Change (UNFCCC) Conferences of the Parties (COP17, COP18, and COP19) have long associated equity issues with both mitigation and adaptation, even though equity concerns expressed at the international level mostly relate to different allocation approaches for climate change mitigation commitments. However, equity issues themselves are generally seen as not place-specific (Rawls, 1971).
2. An "open indicator" approach allows for all conceivable indicators to be included. Difficulties with indicator-based approaches, such as the ERF, highlight geographic variation in costs of action, impacts, and capabilities as well as related divergent views on good principles and the indicators to be used (Kallbekken et al., 2014). With an open indicator approach, however, each national government might use those indicator(s) most suitable to its own interests in order to minimize ambition and display its stance in a more favorable light (Kallbekken et al., 2014). This could undermine the implementation of measures. Some scholars therefore call for region-specific equity indicators (e.g., McDermott et al., 2011).
3. A "bounded flexibility" approach offers a spectrum of commitments within a "template" of agreed indicators (Kallbekken et al., 2014). The idea is to develop a finite, official list of indicators, agreed upon by an expert process, and allow each entity to decide which of these indicators to monitor.
4. The equity framework approach of McDermott et al. (2011) allows analyzing how equity is addressed in policies and assessing its baseline status. This approach is based on analysis of the local and regional policy arena and on identifying particular social contexts, norms, and values. The framework targets four parameters of equity that should be considered in the planning or assessment of a policy or project: its content, target, goals, and process. McDermott et al. (2011) suggest that policy analysts start by analyzing equity goals. Goals may be to maximize or improve equity, to "do no harm," or simply not to worsen

the current situation. When setting targets, it is important to determine who counts and at what spatial, temporal, and social scales. At this stage, crucial decisions have to be made, and a more inclusive assessment is generally preferable, especially the participation of vulnerable groups. It is assumed that the equity framework helps in analyzing tradeoffs between sectors or impacts on different target groups and in ordering or weighting rights that can conflict with each other, such as growth versus sustainability, rights of indigenous people versus migrants (or majorities), and current versus future responsibilities and duties (McDermott et al., 2011).

We use the ERF as starting point and develop it further to reflect more fully those concerns related to equity in urban areas. We see the need to provide one framework for mitigation (see Figure 6.5a) and another for adaptation (see Figure 6.5b) in order to increase specificity, although adaptation and mitigation efforts in urban areas should be conceptualized jointly to avoid mal-adaptation or mal-mitigation. The mitigation framework for urban areas recognizes the importance of the Paris Agreement on the total global efforts needed to keep global warming to 2°C above pre-industrial levels (with the ambition to limit warming to 1.5°C), but also the key contributions required from municipal governments and the extent to which achieving this global goal depends on appropriate support for city and municipal governments from national governments and international agencies. The adaptation framework (see Figure 6.5b) recognizes urban centers and their urban governments as its starting point (not national governments and international agencies), acknowledging what they can do directly and how they can support contributions from citizens, civil society, the private sector, and other stakeholders.

Additionally, we present the Urban Equity Impact Assessment (EquIA-urban) tool based on McDermott et al. (2011), for use by urban decision-makers and community groups that are implementing climate actions and want to review the likely effects in light of potential equity issues. This assessment offers hands-on, step-by-step guidance when implementing climate change policy measures in urban areas (see Table 6.2).

6.6 Knowledge Gaps, Future Research, and Awareness-Raising

To improve assessment of the influence of climate change on equity in cities, research is needed on all dimensions of climate change (i.e., impacts and risks, adaptation and mitigation).

6.6.1 Data Requirements and Research Needs

- To date, most urban climate change-related impacts and risks across gender, age/generation, ethnicity, social classes, and demographic groups have been qualitatively described but are not well quantified, thus impeding structural comparisons. Shortcomings also exist with respect to adaptation and adaptive capacity.

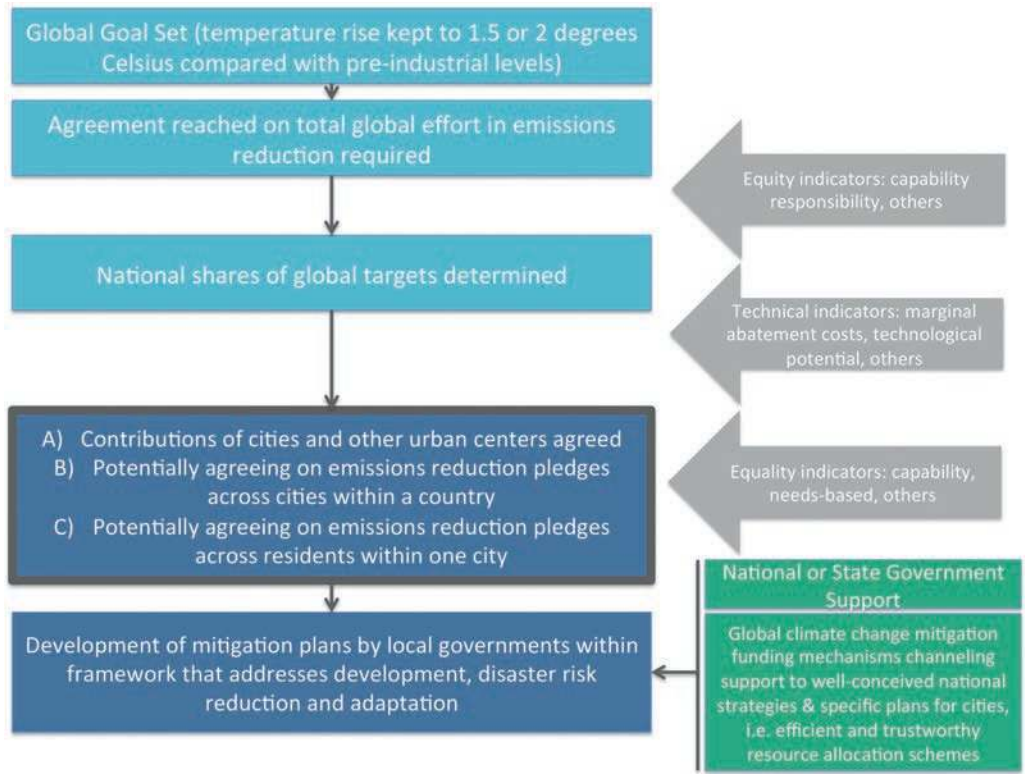

Figure 6.5a *Equity framework for addressing mitigation in urban areas.*

Source: Based on CAN Equity Group, 2014. Modified for urban areas.

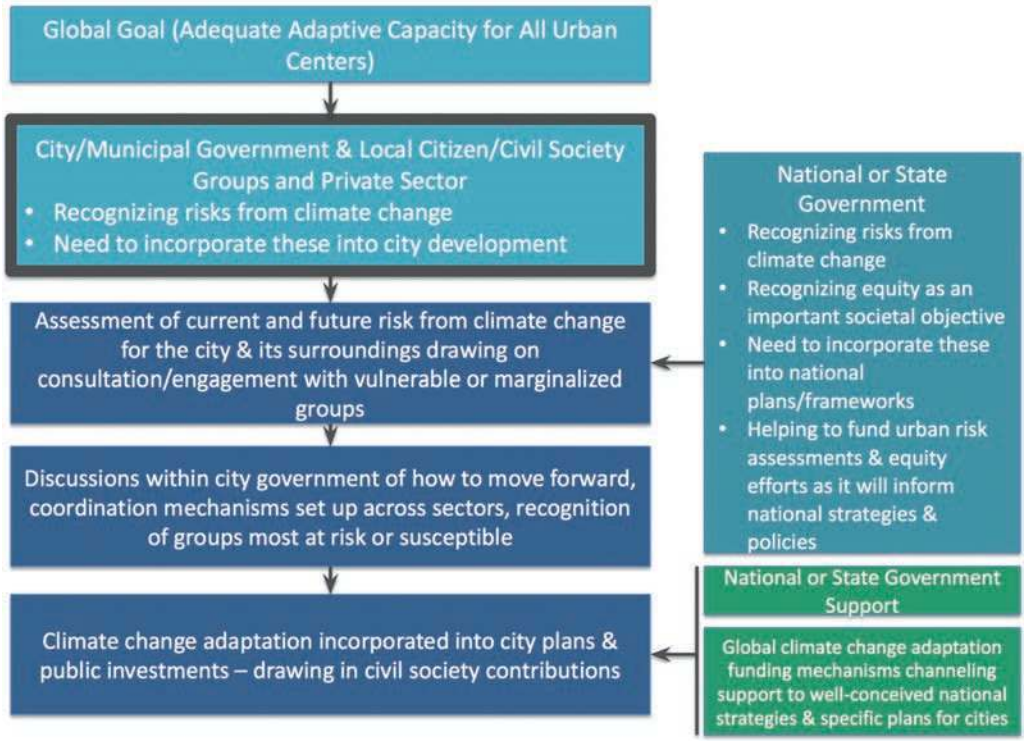

Figure 6.5b *Equity framework for addressing adaptation and adaptive capacity in urban areas.*

Source: Based on CAN Equity Group, 2014. Modified for urban areas.

Table 6.2 *Urban Equity Impact Assessment (EquIA-urban) tool: A step-by-step guide. Source: Adapted from McDermott et al., 2011*

The Urban Equity Impact Assessment (EquIA-urban) tool: A step-by-step guide
This guide summarizes important questions that need to be considered when defining the dimensions and parameters of climate change policies in order to understand their likely impact on urban equity. Following this guide and discussing these questions will minimize the risk that a policy measure will have unintended, inequitable consequences following its implementation.

1) **Process: How are the parameters of urban equity set?**
   What is the decision-making process in framing the initiative?
   How is it established and at what scale of decision-making?
   Who is included/excluded in the decision-making process?
   Who defines the goals, targets, and content of the initiative?

2) **Goal: Why equity? What is the explicit/implicit goal?**
   Is the goal to maximize urban equity, to improve equity, or to do no harm? Or are equity impacts not under consideration?

3) **Target: Who counts as a subject of equity?**
   At which scale(s) is equity considered: individual, household, community, city, value chain, or regional? Consider multiple scales to prevent negative side-effects for others.
   How are the needs of current and future urban generations taken into account?
   How are the needs of nonhuman species or urban ecosystems taken into account?

4) **Content: What counts as a matter of urban equity?**
   4a) Distributive equity
   Has the distribution of benefits, costs, and risks across urban residents been considered?
   What is the intended basis for the distribution of benefits: e.g., equal shares, net social welfare, merit, needs?
   What is the intended cost-benefit distribution, and what will its impacts be?
   4b) Procedural/participatory equity
   Who is participating in decision-making, and who is left out?
   Which underrepresented groups are recognized? Can they voice their interests and be heard?
   4c) Contextual equity (incorporating capabilities, access, power)
   Do decisions reflect the interests of the under-represented groups?
   Do under-represented individuals have access to the resources (e.g., land, capital) necessary to secure benefits of the initiative?
   What new capabilities are being developed (e.g., economic opportunities)?
   What local institutions provide "safety nets"?
   Are the causes of inequity identified? Are they addressed?

Adaptation and adaptive capacity are difficult to assess for a variety of reasons, including lack of accepted definitions and the abstract nature of the qualities of flexibility and inventiveness. Regarding mitigation, research needs relate to calculating fair assessments of pledges for cities, neighborhoods, and social classes.

- In general, the spatial, social, and temporal resolution of statistical data has to be improved (Martine and Schensul, 2013; Guzman and Miguel, 2009; Montgomery et al., 2003).

The resolution of most available data – including climate records, disaster incidence, disaster losses, and climate projections – is generally much coarser than a city's spatial extent. And yet even finer spatial disaggregation is needed if we are to understand how the risks and vulnerabilities of any given city are likely to vary across its heterogeneous districts and neighborhoods. Similarly, more information is needed on the spatial extent of cities and their expansion or contraction. It would be useful to have data for separate risk areas, such as coastal regions. There have been important advances drawing on satellite imagery (World Bank, 2015; Angel et al., 2011), but much work remains to be done on methodology, image-processing algorithms, and validation before a globally consistent, spacio-temporal view of urban areas can be created (Small, 2005).

- Demographic data on cities will also need to improve (Montgomery et al., 2003).

Most demographic information is currently based on national samples, which are inadequate to portray urban realities and hide the scale and depth of inequality within urban populations (with the exception of a few estimates of demographic characteristics that are available for very large cities). Moreover, national data and censuses are usually only undertaken every ten years, which is insufficiently frequent to capture more rapid urban developments. Providing census data in fine geographic detail on the neighborhood level could be a worthwhile starting point.

- Studies need to examine the correlates, root causes, and cascading impacts of climate risk in cities, and urban risk typologies (i.e., confounding, reinforcing, and dampening factors of risk and their interrelationships).

Research to date includes instructive general accounts of the consequences of extreme events that are vividly illustrated by compelling case studies. But in its present form, the evidence base for impact comparison across hazards is grossly inadequate, particularly for local and smaller-scale events. For example, causes of death and health risks are well recorded in high- but not in many low- and middle-income countries. The most important international disasters database, DISINVENTAR (EM-DAT, 2010), does not record the precise locations of events within a country, nor is it able to go beyond tallying the numbers of people killed or affected to provide demographic information. If combined with spatially disaggregated socioeconomic information from population censuses or related sources such as the World Bank's Small-Area Poverty Mapping project (Elbers et al., 2003, 2005), the DESINVENTAR data could shed light on the occurrence and impact of disasters at a community level (Marulanda et al., 2010). Shortcomings also exist with respect to research on financial consequences. The costs of rebuilding as well as the costs of adaptation or prevention are policy concerns that need to be addressed in research.

- Micro-level longitudinal and retrospective sample surveys can enable reconstruction of before-and-after portraits of affected individuals and neighborhoods (Fernanda Rosales, 2014).

Linking GIS mapping of impacts or potential risk indicators with estimations of social vulnerability is another promising way forward to assess relations between climate-related impacts and their socioeconomic effects (Cutter and Finch, 2008).

- There is also the need for more qualitative social research.

This should include improving the gender perspective, which relates to both the disproportional impacts of climate change on women in cities and the contributions of women as key agents of change for mitigation and adaptation. With respect to social processes, research should explore the differentials based on gender, age, ethnicity, social class, and demography with respect to access, use and control of resources, level of assets, and disaster preparedness. Progress is also needed in integrating attitudes, perception, and abilities in the quantification of climate risks and vulnerabilities because these are related to adaptation and mitigation willingness for action. One interesting approach is *fuzzy cognitive mapping*, which aids in assessing the relative impact of weather events among individuals and groups producing socially feasible adaptation options (Reckien et al., 2011, 2013, 2014).

- Research needs to investigate enablers of change toward more resilient and equitable urban environments.

The research community has often identified key risk factors but not the enablers of change toward more resilient and equitable urban environments. Because the processes that exacerbate inequity, vulnerability, and risk may not match the processes that promote equity and resilience, there is substantial need to investigate factors that can foster positive change, such as involving women's organizations in climate change planning processes.

- Overall, there is a need for conceptual frameworks, methodologies, and tools for measuring and monitoring climate change-related equity aspects in cities.

The EquIA-urban tool presented in Table 6.2 provides an important entry point, but needs to be further developed to allow for operational, comparable assessments.

Table 6.3 *Concrete policy recommendations for climate change and policy domains covered in this chapter*

Climate change domain	Policy domains	Potentially useful recommendations	Responsibility
All	General equity concerns	• Provide risk-reducing infrastructure and services across all urban neighborhoods • Account for "development-accumulated" risk and take into account lessons from previous disasters; avoid creating "new risk" • Create awareness among low-income populations about likely impacts of climate change, including differential impacts on women, children, the aged, immobile residents, and ethnic groups • Disseminate the principles of minimal safety standards in low-income housing • Ensure safety standards in legal housing • Build capacity of community-based organizations to address local risks through local infrastructure solutions and services	City authorities, civil society organizations, neighborhood organizations and/or committees
Impacts and risks	Policy recommendations *Heat Stress*	• Establish neighborhood watch groups to support lonely elderly people during heat waves • Inform residents of the differential vulnerabilities of women to heat related to physiological characteristics as well as to work environments • Provide sustainable public green space (plus management) in low-income urban areas • Promote urban forestry and establishment of urban nature reserves • Look after open water bodies in urban areas, particularly to protect them from littering and encroachment	Neighborhood and housing organizations, planning offices, landscaping professionals and contractors
Impacts and risks	Policy recommendations *Inland Flooding*	• Establish safe destination areas for newly arrived migrants • Adopt sustainable urban drainage design principles in addition to stabilization of riverbanks to prevent flooding of residential areas • Increase drainage capacities and systems, particularly in low-income communities • Improve the functioning of upstream and downstream drainage systems across entire urban area	City authorities, planning departments, engineering departments, developers
Impacts and risks	Policy recommendations *Landslides*	• Develop environmental protective infrastructure on hill slopes (i.e., plant trees and other soil-fixing greenery) • Implement sustainable-upgrading measures like paving of streets and walkways on hill slopes; include mandatory improvement and reinforcement of draining systems in order to channel runoff during and after heavy rainfall events	City authorities, planning departments, engineering departments, developers
Impacts and risks	Policy recommendations *Drought*	• Diversify urban water supply in cities in dryland ecosystems • Diversify the electricity supply in dryland regions • Plan for an increase in intensive rainfall during periods of droughts (i.e., through infrastructure solutions that cater to both extremes – water shortage and water excess at the same time) • Provide additional support to low-income households and women in times of high food prices and food insecurity	City authorities, community organizations
Impacts and risks	Policy recommendations *Storm Surge and Coastal Flooding*	• Keep flood plains and coastal zones free of new developments in order to avoid constructing new risks • Establish coastal buffer zones (e.g., beaches, marshes, dunes, and mangroves) • When redeveloping coastal zones, integrate measures to prevent pollution from industrial harbor activities • Inform low-income households and other people at risk of health risks and the transmission pathways of diseases likely to occur after floods and storm surges • After an event, target support to low-income communities, ethnic minorities, the elderly, and other groups with low coping capacity • Establish disaster relief aid, such as bus lines and neighborhood watch programs • Inform particularly vulnerable citizens about community relief programs	City authorities, planning departments, engineering departments, developers

Table 6.3 (*continued*)

Climate change domain	Policy domains	Potentially useful recommendations	Responsibility
Adaptation	Policy recommendations *Adaptation*	• City governments are advised to provide the network infrastructure and institutional services required to build community resilience, particularly in low-income neighborhoods • City governments are advised to take measures to counteract policy decisions by national governments that increase the vulnerability of the poor, women, and other underrepresented groups • Foster individual and community self-help, where possible, linked to new economic opportunities for low- and middle-income residents • Establish disaster response agencies and strengthen the emergency services; take measures to build their capacity	City authorities, planning departments, developers
Mitigation	Policy recommendations *Spatial Planning*	• Focus on mixed land use and urban density • Be aware of and attempt to lower possible negative side effects of compact city spatial planning models on low-income neighborhoods and ethnic communities (e.g., by using social policy to cap accommodation prices and rents for households in need) • Secure the continuation of social housing policies even for housing built to (expensive) low-carbon housing and construction standards • Combine densification programs with measures to improve public transport • Find innovative ways to provide recreational areas in compact neighborhoods (e.g., through green roofs and including recreational facilities in multistory structures), so people don't have to drive to recreation areas • Secure availability and access to green space in low-income and ethnic communities • Finance densification with development taxes imposed on new development to cover infrastructure-related costs, to reduce the relative burden for low-income groups	City authorities, planning departments, developers
Mitigation	Policy recommendations *Accessibility and Transport Policy*	• All new urban areas shall be serviced by efficient public transport routes • Improve the accessibility, safety, and comfort of public transportation • Prioritize women's perspectives in public transport schemes (e.g., allow request stops during the night) • Reduce out-of-pocket fees for public transport schemes (e.g., by allowing monthly and annual passes to be paid for in multiple installments) • Provide unlimited-use passes for public transport (not multiride schemes based on number of transfers, which disproportionally affect the poor and women) • For private transport, create high occupancy toll lanes	City authorities, planning departments, developers

6.6.2 Awareness-Raising

Meeting information needs refers not only to generating the required data but also to ensuring that these data are communicated or made accessible, and understandable to the people who "need to know." Thus, actions to spread awareness and transmit know-how are a necessary (but not sufficient) intervention to promote equity and climate resilience in cities. The forgoing discussions show that environmental justice policies have evolved in some cities while in many other cities existing policies have inequitable impacts on the urban poor and other disadvantaged groups. There are cases of cities with long-standing municipal laws and policies that obscure the realities of equity issues, such as those revealed by flood disasters in Bangkok and New Orleans.

Raising awareness of the importance of equity and equality issues in relation to climate change in cities will be key for sustainable urban futures. Working with environmental justice groups can make an important contribution to increasing awareness, bringing equity issues to the forefront and promoting the inclusion of equity into city plans and policies. Particular attention should be paid to the need for equity between women and men because gender inequality is often overlooked in climate impacts, adaptation, and mitigation studies; disaster-relief programs; and policies. Another concern relates to particularly hard-to-reach populations, which are often underrepresented and unheard. (Sampson et al., 2013).

In summary, the following actions can help raise awareness of equity in cities:

1. Document and communicate climate change impacts and adaptation capacities as well as information on access, use, and control of resources, assets, and preparedness in relation to gender, age/generation, ethnicity, social class, and demographic groups.
2. Document and communicate the correlates, root causes, and cascading impacts of climate risk in cities and their fine-grained spatial distribution.
3. Develop capacity-building tools for urban stakeholders and authorities to mainstream gender, intersectionality, and other equity issues into their plans and actions.
4. Identify ongoing community processes and women's initiatives that should be acknowledged and incorporated into municipal action plans.
5. Ensure gender-balanced decision-making processes and integration of other underrepresented groups into policy-making spheres. Integration should transcend numerical representation to encompass issues of social empowerment and political influence, keeping in mind the need to reach out to particularly hard-to-reach populations.

Despite the existing challenges to the integration of equity in city policies related to current climate change risks, impacts, and adaptive capacities, the need to respond to newly emerging risks will be even more difficult to communicate. A multi-level approach to raising awareness is needed to enable communities and actors of both public and private sectors to understand the potential magnitudes and impacts of risks that have yet to become apparent and the need to account for uncertainties in long-term climate change plans and policies.

6.7 Policy Recommendations

Projected ongoing climate change and the likely occurrence of more climate extreme events, in combination with continuing rural–urban migration across the world, make addressing inequity and inequalities a major challenge for urban policy-makers. In this final section, we propose a series of policy recommendations based in part on the results of a stakeholder survey (see Annex Box 6.1).

Urban policy should integrate equity and environmental justice as a primary long-term goal because equity fosters human well-being, social capital, and sustainable social and economic urban development. There is an urgent need to complement attention to short-term needs with measures to address climate risks projected in the medium to long term. The goal is to avoid short-term responses that may ultimately prove to be "maladaptive," in particular by placing an increasing burden on the most vulnerable in society.

Climate policy should show greater sensitivity toward the vulnerability of the urban poor, women, and the elderly, as well as to the discrimination faced by women, ethnic minorities, and other underrepresented groups who lack access to adequate urban services and infrastructure. In framing and implementing climate policy, it is essential to continually take into account gender outcomes and other equity issues. Particular attention must be paid to the economic and social consequences of climate change policy in urban areas.

Access to land, security of tenure, basic services, and risk-reducing infrastructure for all urban residents, and particularly for vulnerable and newly established urban communities, is crucial for reducing inequalities and the equitable distribution of risk-reducing benefits. Growing urban centers require increased investment in services and infrastructure, and this needs to be targeted at vulnerable groups and neighborhoods.

Urban policy should incorporate community views regarding what is resilient and feasible by promoting participatory approaches and avoiding top-down, inflexible solutions. Policymakers need to learn to appreciate existing cultural knowledge and values and to integrate these into the planning processes. Engaging local residents at the beginning of the process and partnering with existing grassroots organizations are key; this can create important educational opportunities and develop the trust and consensus necessary for moving from conceptualization to implementation of adaptation actions.

There is need for cities to promote a shared science–policy interface for improved integration of multiple (sometimes conflicting) stakeholder interests in the policy-making process. Shared science–policy interfaces enable better communication among scientific institutions, think-tanks, and application-oriented stakeholders and policy-makers while facilitating the identification of common interests and shared understandings. At a local level, this work can usually be led by a "taskforce" or "focal point" prominently located in a large and financially strong municipal department (i.e., close to the Mayor's office). Close coordination between urban and national representatives is indispensable to avoid national policy frameworks that impede equity and environmental justice efforts at the urban level.

Long-term financial mobilization and institutional support for addressing both climate change and equity concerns are essential to ensure that adaptation and mitigation interventions in urban areas are equitable and inclusive. Combining traditional and nontraditional sources of finance, including community contributions, is crucial for equitable risk reduction. Poorer communities need stronger multilevel governance arrangements supported by more effective international, national, and municipal financing mechanisms that are able to channel resources toward local projects that help the poorest and most vulnerable groups to adapt to climate change.

Fair resource allocation schemes, budgetary transparency, and progress measurement are essential to make sure that funds reach their target groups. Metrics to measure progress on adaptation and mitigation should also monitor their effects on equity, equality, and environmental justice in urban areas. Urban statistical databases need to be developed and improved (see World Council on City Data, www.dataforcities.org). Cities should build up their own urban statistical data-gathering and monitoring

Box 6.4 Demographic Composition and Change

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Demography, the study of human population, provides a view into understanding inequalities of populations at risk of the consequences of climate change and inherent inequalities in the relationship between population change and emissions, with important resulting implications for both adaptation and mitigation. Populations vary in their size, structure, and distribution of the population and subgroups thereof. They change over time and space, with urbanization currently and over the coming decades projected to be one of the most significant population changes.

As seen in Box 6.4 Table 1, the world today is home to 7.3 billion persons. By the end of the century, the United Nations estimates that the world population total will exceed 11 billion, with more than 4 billion residents each in Africa and Asia. While the population of Asia will grow and then decline in the coming century, the largest rate of growth will occur in Africa. According to the UN, the world population currently continues to grow, although more slowly than in the recent past. Ten years ago, world population was growing by 1.24% per year. Today, it is growing by 1.18% per year, or approximately an additional 83 million people annually.

As with any type of projection (such as that shown in Box 6.4 Table 1, for the medium-variant), there is a degree of uncertainty surrounding these population projections. The medium-variant projection assumes a decline of fertility for countries where large families are still prevalent as well as a slight increase of fertility in several countries with fewer than two children per woman on average. Survival prospects are also projected to improve (i.e., mortality rates are expected to decline) in all countries.

Box 6.4 Table 1 *Population of the world and major areas, 2015, 2030, 2050, and 2100, according to the medium-variant projections. Source: UN, 2015*

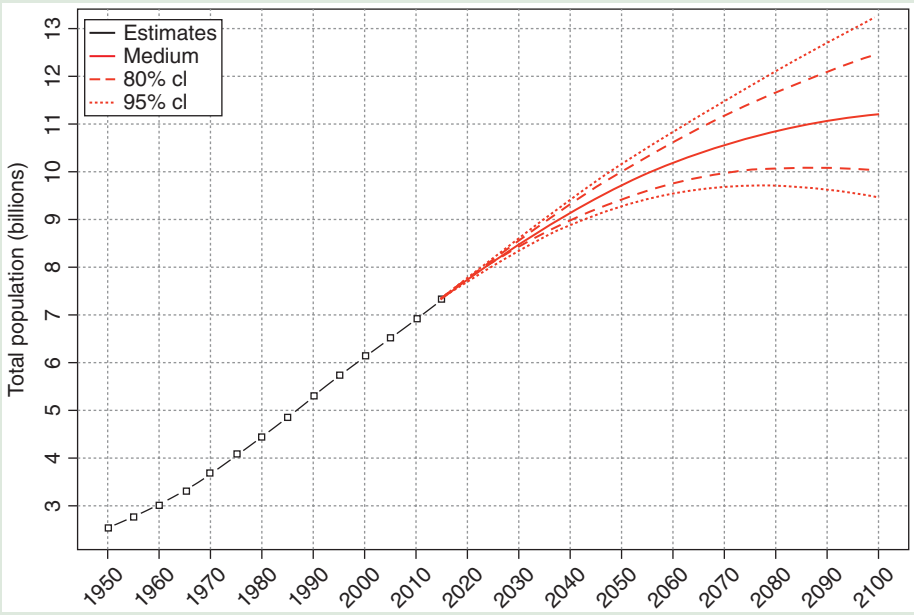
	Population (millions)			
Major area	**2015**	**2030**	**2050**	**2100**
World	7,349	8,501	9,725	11,213
Africa	1,186	1,679	2,478	4,387
Asia	4,393	4,923	5,267	4,889
Europe	738	734	707	646
Latin America and Caribbean	634	721	784	721
Northern America	358	396	433	500
Oceania	39	47	57	71

Uncertainty tends to increase the further out in time one projects. The UN Population Division uses statistical methods to make statements about the degree of uncertainty around this medium-variant projection. Box 6.4 Figure 1 shows that one can say with a 95% degree of confidence that global population will be between 8.4 and 8.6 billion in 2030 and between 9.5 and 13.3 billion in 2100. In other words, global population is virtually certain to rise in the short- to medium-term future. Later in the century, global population is likely to continue to rise, but there is roughly a 23% chance that it could stabilize or begin to fall before 2100 (UN, 2015).

The world of the future will, demographically speaking, be older and more urban. The world of today has twice as many children under age 15 than persons over age 60, but by mid-century the number of those 60 and older will have doubled, and there will be parity between those under age 15 and those over 60. Some regions, notably Europe, already have around one-quarter of their population aged 60 or older. A few years ago, the world population turned for the first time from majority rural to majority urban. With high proportions of city-dwellers in the Americas, Europe, and industrial countries of Asia and Oceania, this trend is seen as irreversible.

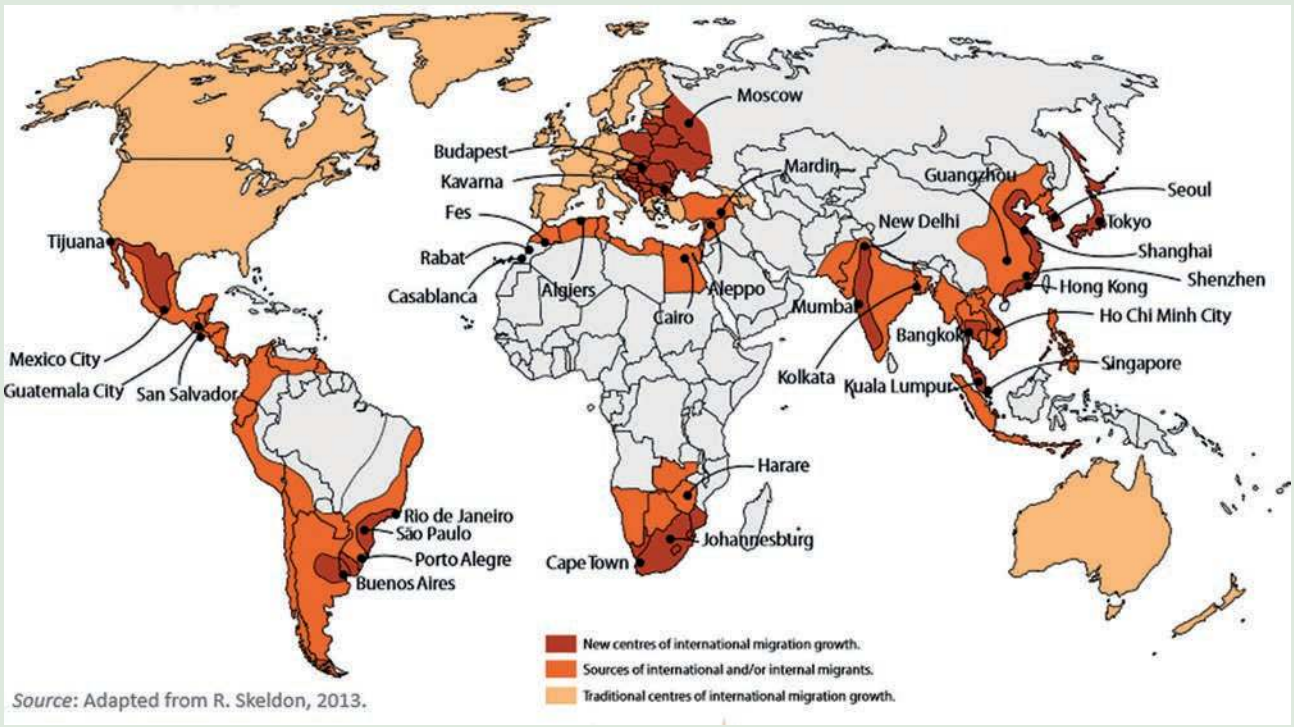
Migrants, while usually better off than those who cannot migrate, tend to be worse off than the native population in the destination location (Greenwood, 1997; Montgomery et al., 2012). In addition to being younger than the native population, they tend to be less educated. Migrants to cities, as well as the urban poor, may also have less access to affordable and safe housing, potable water and sanitation, social services (health care and education), and employment, although systematic evidence finds that migrants are not uniformly disadvantaged (NRC, 2003). This unequal access, where it exists, places migrants and the poor at greater risk for the consequences of climate change or other natural disasters. As fertility declines, it is likely that migration will play an increasingly important role in the character of cities: thus the importance of improving our understanding of migration and migrant well-being, as well as that of the urban poor more generally.

Cities are densely populated relative to the surrounding areas. Population density is not necessarily thought of as a dimension of inequality, in some part because density allows for the provision of municipal services and goods that reduce inequality. However, cities are not uniformly dense. Poor persons tend to live in more crowded parts of cities, and crowding may exacerbate adverse climate conditions (e.g., excess heat or flooding), foster disease transmission, limit escape routes where public space is insufficient, and cut people off



Box 6.4 Figure 1 *Population of the world: estimates, 1950–2015, medium-variant projection and 80% and 95% confidence intervals, 2015–2100.*

Source: UN, 2015



Box 6.4 Figure 2 *Global diversification of migration destinations.*

Source: IOM, 2015. Adapted from Skeldon, 2013

from access to critical services and emergency response. In a case study of Vietnam, it was found that the urban poor were much more likely to live in the low-lying areas of cities in low-lying coastal zones rather than in higher elevation portions of those cities or in higher-elevation cities altogether (Balk et al., 2009).

To better understand the change that cities will undergo in the coming century, demographic data on cities will need to improve. Demographic data are typically collected through population censuses, surveys, and vital registration systems. While the reporting unit varies, typically, demographic estimates from censuses are tallied for administrative units such as counties rather than cities *per se*, except for the very largest ones. Surveys that produce demographic estimates are usually representative at the national level or, at best, the first-order subnational level, such as states or provinces, but rarely cities, with the occasional exception of the largest or capital cities. Surveys usually allow for tallying population into urban and rural strata, but that is not sufficient to understand different demographic profiles by city type and characteristics. Census data from national statistical offices, even when reported for small enumerator areas, are never reported for specialized land areas such as coastal regions; thus, understanding the lives of coastal city dwellers requires additional access to fine-resolution or micro-data records that are often impossible to acquire. In order to better meet the needs of city and regional planners and for national policy-makers to understand the demographic shifts of the future, particularly in the context of climate and other environmental change, greater attention to the spatial location of census data and sampling frames for survey data are essential (Martine and Schensul, 2013).

For more coverage on this topic, see Box 1.1

offices and lobby national agencies to collect city-specific data on equity and equality markers. Focusing on these issues may also contribute to institutionalizing progressive changes in planning and policy practice.

Policy needs to be continuously re-evaluated, reassessed, and readjusted in order to make cities sustainably equitable. Because social categorization and stratification are always evolving, equity and environmental justice are not an outcome achieved once and for all, but one that is negotiated in an ongoing process. The EquIA-urban tool is a step-by-step guide supporting such a process. Achieving an equitable response by cities to the multiple challenges of climate change will require participation from all social groups and ongoing commitment to both climate change and equity objectives by policy-makers and civil society. More detailed recommendations for particular climate change events and policy domains are summarized in Table 6.3

Annex 6.1 Stakeholder Engagement

Every urban stakeholder is an important source of knowledge of how equity in cities might be affected by climate change and a potential user of the final product of this assessment. As co-producers of knowledge, stakeholders were involved in the production of this chapter as authors, advisors, and reviewers. Lead stakeholders submitted contributions and examples of their work as Case Studies (see Boxes 6.2 and 6.3). They were also involved in the chapter's new piece of research, conducting a questionnaire survey to elicit the experience of UN-Habitat partner organizations with equity and environmental justice issues in cities. The results of the questionnaire survey contributed to recommendations for policy (see Annex Box 6.1). Lead stakeholders were the New York City Environmental Justice Alliance (NYC-EJA) and the Women's Environment and Development

Annex Box 6.1 Policy Recommendations from the Ground, Elicited through Stakeholders of UN-Habitat

As part of the chapter's research, stakeholders of UN-Habitat were contacted and asked about their experience of equity and environmental justice issues in their work. The questionnaire also asked respondents to suggest indicators that should be monitored after the implementation of climate change policies in order to ensure that there are no negative side effects on equity dimensions. The following text summarizes the responses:

Who is disproportionately affected?

- Low-income groups and people living in low-standard housing, as well as middle- and high-income residents
- People dependent on natural systems and climate-dependent livelihoods (fisheries, agriculture, tourism) are particularly affected, as are women, children, the elderly, and people with disabilities and reduced rights (migrants, minorities, socially and ethnically discriminated groups)

What are the reasons for vulnerability?

- Residency in vulnerable locations, such as riverine areas, urban fringes, and areas affected by inadequate service provision and deficits in urban planning (e.g., lack of protective infrastructure and/or deficient infrastructure, failure to enforce building standards)
- Inadequate urban governance and absence of commitment by locally elected representatives to tackle environmental issues

- Deficiencies with respect to empowerment, entitlement, management, literacy, and social capital among the vulnerable; a general lack of assets, wealth, and insurance cover were also mentioned

Which factors should be monitored to ensure no detrimental effects on equity from climate change policies?

- Achievement of fundamental aims of climate change policy, such as reduced impacts or increased resilience
- Proportion of population living in disaster-prone locations, substandard housing, below the poverty line, and with reduced access to basic urban services
- Unintended side effects of climate change policies on equity and effects on regional and local water supplies, as well as effects on women and the young

Important factors believed to increase equity in urban areas under conditions of climate change:

- Risk-reducing infrastructure and services (e.g., public roads with drainage systems) should be provided across the entire metropolitan region
- Construction of stronger houses, prevention of housing in riverine areas, control of soil erosion and surface runoff, and promotion of greenbelts and urban forestry (as windbreaks and natural protection)
- Permanent financing mechanisms for climate change policies and actions in cities through harnessing of local and international finance mechanisms and partnerships; prioritization of credits to finance small-scale enterprises and those based on the use of natural resources
- Institutional arrangements (e.g., support provided by community-based and non-governmental organizations (CBOs and NGOs)
- Policies that focus on increasing economic opportunities for residents (e.g., as seen in the green and smart cities initiatives)
- Training and education to raise awareness of climate change risks and impacts and build the capacities of communities to take appropriate action; education of citizens about the role of cities and city governments in responding to climate change
- Mobilization of community leaders to encourage commitment of elected representatives and to provide examples of municipal leadership
- Resilience and integration of low-carbon development into broader sustainable urban development initiatives

Organization (WEDO). Contributing stakeholders included the Municipality of Bobo-Dioulasso (Burkina Faso), Ministry of Environment and Fishery Resources (Burkina Faso), and UN-Habitat (Main Office and Regional Office for Asia and the Pacific [ROAP]).

Chapter 6 Equity and Environmental Justice

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