3

Disasters and Risk in Cities

Coordinating Lead Authors

Ebru Gencer (New York/Istanbul), Regina Folorunsho (Lagos), Megan Linkin (New York)

Lead Authors

Xiaoming Wang (Melbourne), Claudia E. Natenzon (Buenos Aires), Shiraz Wajih (Gorakphur), Nivedita Mani (Gorakphur), Maricarmen Esquivel (Washington, D.C./San José), Somayya Ali Ibrahim (New York/Peshawar), Hori Tsuneki (Washington, D.C.), Ricardo Castro (Buenos Aires), Mattia Federico Leone (Naples), Dilnoor Panjwani (New York), Patricia Romero-Lankao (Boulder/Mexico City), William Solecki (New Brunswick/New York)

Contributing Authors

Brenda Lin (Melbourne), Abhilash Panda (Geneva)

This chapter should be cited as

Gencer, E., Folorunsho, R., Linkin, M., Wang, X., Natenzon, C. E., Wajih, S., Mani, N., Esquivel, M., Ali Ibrahim, S., Tsuneki, H., Castro, R., Leone, M., Panjwani, D., Romero-Lankao, P., and Solecki, W. (2018). Disasters and risk in cities. In Rosenzweig, C., W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, and S. Ali Ibrahim (eds.), *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*. Cambridge University Press. New York. 61–98

Disasters and Risk in Cities

The effects of climate-related disasters are often exacerbated in cities due to interactions with urban infrastructure systems, growing urban populations, cultures, and economic activities. Because the majority of the world's population is currently living in cities – and with this share projected to increase in the coming decades – cities need to focus on improving responses to climate-related disasters such as heat waves, floods, and droughts.

In a changing climate, a new decision-making framework is needed in order to manage emerging and increasing risks. This involves a paradigm shift away from attention to single climate hazards based on past events. The new paradigm requires integrated, system-based risk assessments and interventions that address current and future hazards throughout entire metropolitan regions.

Major Findings

- The environmental baselines of cities have started to shift as climate change impacts take hold. More frequent climate and weather extreme events are being experienced in some urban areas. The frequency and severity of weather and climate-related disasters in urban areas are projected to increase in the coming decades.

- Cultural, demographic, and economic characteristics of urban residents, city governments, built environment, ecosystem services, and human-induced stresses, such as over-exploitation of resources and environmental degradation, define the vulnerability of cities to climate-related disasters. Environmental conditions resulting from unplanned urbanization including removal of natural storm buffers, air and water pollution, overuse of water, and the urban heat island effect exacerbate impacts of climate disasters.

- Given that more than half of the world's population lives in urban areas and that this percentage is expected to significantly increase in the next decades, cities must focus attention on disaster risk reduction and enhancing resilience, issues that most smaller cities have not addressed. Assuming that urban decision-makers have the necessary institutional capacity, their ability to ensure resilient futures could be redirected through strategic development initiatives such as effective risk management, adaptation, and urban planning systems.

- Integrating climate change adaptation with disaster risk reduction involves overcoming a number of barriers. The key barriers include lack of climate resilience in a city's development vision; limited understanding of the hazards, vulnerabilities, and resulting risks; lack of coordination between administrative and sectoral levels of city management; inadequate implementation and financial capacities; and poor connection between climate adaptation and risk management efforts and cities' development visions and strategies.

- Central strategies for improving resilience and managing risks in cities include the integration of disaster risk reduction with climate change adaptation; land-use planning and innovative urban design; financial instruments and public–private partnerships; management and enhancement of ecosystem services; strong institutions and communities; and effective pre- and post-disaster recovery and rebuilding.

Key Messages

Disaster risk reduction and climate change adaptation are the cornerstones of making cities resilient to a changing climate. Integrating these activities with a metropolitan region's development vision requires a new, systems-oriented approach to risk assessments and planning. Moreover, since past events can only partially inform decision-makers about emerging and increasing climate risks, risk assessments must incorporate knowledge about both current climate conditions and future projections.

A paradigm shift of this magnitude will require urban decision-makers and stakeholders to increase the institutional capacity of many communities and organizations to apply a systems lens to coordinating, strategizing and implementing risk-reduction, disaster response and recovery plans on a flexible and highly adaptive basis. As a result, the promotion of effective multilevel governance and multi-sectoral and multi-stakeholder integration is critically important (see Chapter 16, Governance and Policy). The demands for transformational adaptation will be significant and require high levels of governance capacity and financial resources.

3.1 Introduction

Climate change-driven extreme natural disasters and the severity of their impacts expose a need for an enhanced policy framework, particularly in urban areas, where the majority of the world's population lives. It is essential to understand the linkages between the impacts of climate change and disaster risks in urban areas and to address integrated strategies for disaster risk reduction (DRR), climate change adaptation (CCA), and resilience building. This chapter explores and assesses these issues.

First, it identifies the fundamental linkages between climate change, hazards, and risks in urban areas, and it explores hazard exposure and the current and potential impacts of climate change in urban areas. The next section focuses on urban vulnerability: socioeconomic, physical, institutional, and environmental vulnerabilities are assessed (see Chapter 6, Equity and Environmental Justice). A new risk assessment and management framework is presented that integrates CCA and DRR options for cities in making decisions that could lead to more effective system-level approaches to implementing strategies.

Disaster risk reduction mechanisms related to urban planning, financial instruments, building capacity, ecosystem services, and post-disaster recovery and reconstruction, are also assessed in this chapter. A particular focus is on integrated approaches to DRR, CCA, and greenhouse gas (GHG) mitigation and the benefits to using such integrated approaches. A section on barriers, challenges, and opportunities serves as the conclusion for the chapter. The section discusses innovative actions and opportunities in urban areas for the integration of DRR and CCA and concludes by providing recommendations for decision-makers.

3.2 Climate Change and Disaster Risk

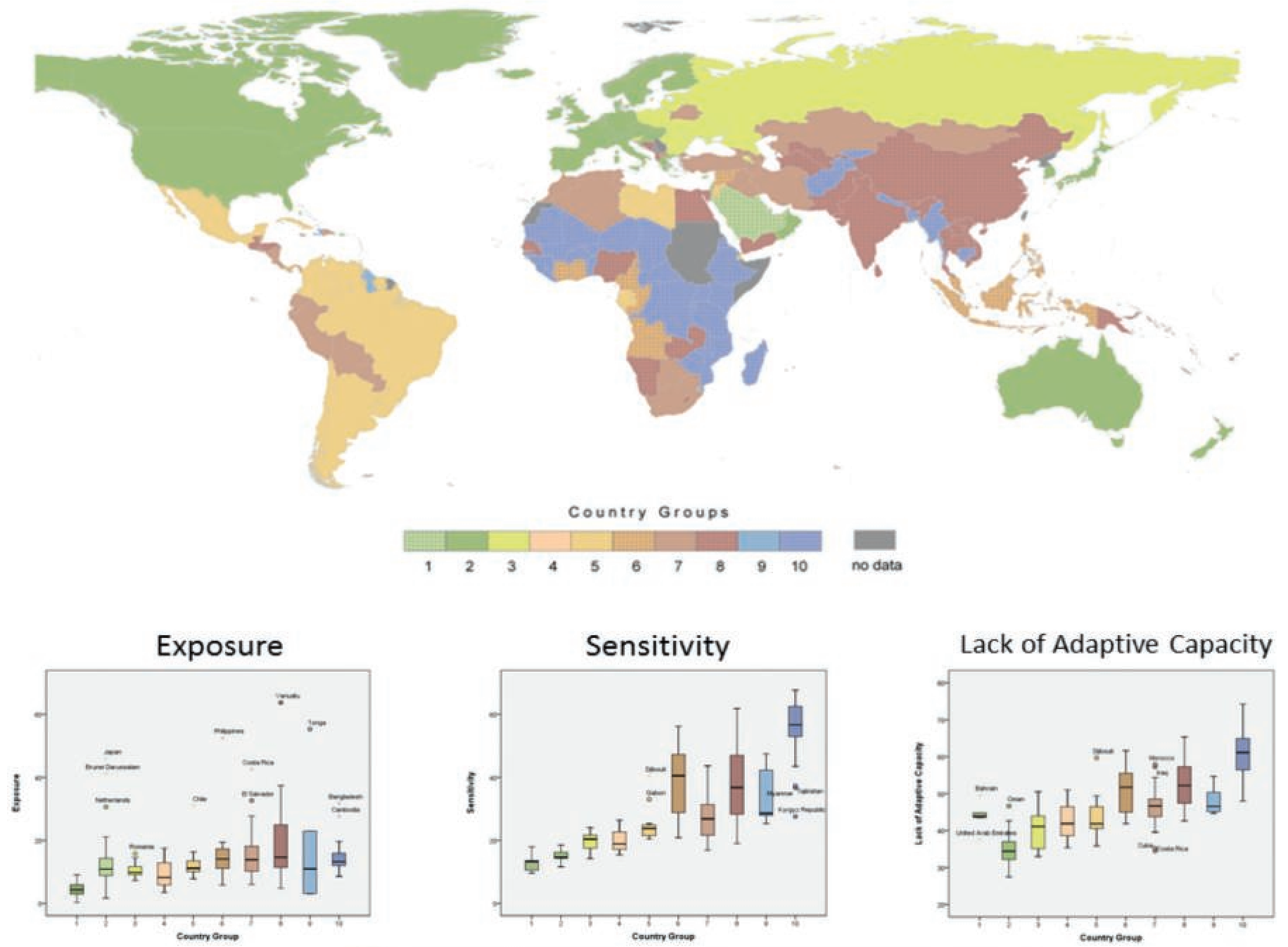
A connection exists between climate change and shifting patterns of risk in cities. In some cases, the linkage is direct because climate change is associated with more frequent and more intense extreme weather and climate events. In other contexts, the connection between the two is mediated by the pathways of urban development and local-scale environmental stresses and degradation. In the following sections, these multiple connection pathways are examined.

3.2.1 Climate Trends

Climate change is expected not only to affect the intensity and the frequency of extreme events, but also to amplify existing social and environmental risks and create novel risks for cities. These emerging conditions result from the interaction of climate hazards (including intense events such as heat weaves and long-term trends such as sea level rise) with the vulnerability and exposure of urban social ecological systems and populations, including their ability to cope, adapt, and transform. These changes have significant implications for cities and urban areas (see Table 3.1).

Table 3.1 *Projected impacts on urban areas of changes in extreme weather and climate events with expected likelihood statements. Source: Romero-Lankao, 2008; Revi et al., 2014*

Climate phenomena and their likelihood	Major projected impacts on urban areas
• Warmer and fewer cold days and nights • Warmer and more frequent hot days and nights *Very likely*	• Reduced energy demand for heating • Increased demand for cooling • Declining air quality • Reduced disruption to transport due to snow, ice • Effects on winter tourism
• Increases in frequency of heat waves *Very likely*	• Reduction in quality of life for people in warm areas without air conditioning • Impacts on elderly, very young, and poor
• Heavy precipitation events more frequent over most areas *Very likely*	• Disruption of settlements, commerce, transport, and societies due to flooding • Pressure on urban infrastructure • Loss of property
• Increases in areas affected by drought *Likely*	• Water shortages for households, industries, and services • Reduced hydropower generation potentials • Potential for population migration
• Increases in intense tropical storms *Likely*	• Damages by floods and high winds • Disruption of public water supply • Withdrawal of risk coverage in vulnerable areas by private insurers • Potential for population migration
• Increased incidence of extreme high sea level *Likely*	• Coastal flooding • Decreased freshwater availability due to saltwater intrusion • Potential for movement of population and infrastructure (also see tropical storms)



1	Very high urbanization, high income, high level of urban population growth, very high to high level of GDP growth
2	Very high to medium-high urbanization, high income, medium to low levels of urban growth, low to very high GDP growth
3	Moderate to medium-high urbanization, medium to high income, neg. urban pop. growth, medium to high GDP growth
4	Moderate urbanization, high income, low to high levels of urban growth, low to very high GDP growth and economy
5	Very high urbanization, middle income, medium to low urban growth, low to very high GDP growth
6	Medium-high urbanization, middle income, high urban growth, medium to very high GDP growth
7	Medium-high urbanization, middle income, low to medium urban growth, low to very high GDP growth
8	Moderate urbanization, middle income, high to low urban growth, very high to high GDP growth
9	Moderate urbanization, middle income, medium to low urban growth, low to medium GDP growth
10	Moderate to medium-high urbanization, low income, high to medium urban growth, low to very high GDP growth

Figure 3.1 *Urbanization and vulnerability. Top: Global distribution of the countries in the ten country groups. Groups 1, 6, 8, and 10 display high urban and economic growth rates. The box plots illustrate the associations between the country groups (x-axes) and exposure, sensitivity, and lack of adaptive capacity. Outliers (i.e., countries with values greater than 1.5 interquartile ranges away from the first or the third quartile) are named.*

Source: Garschagen and Romero-Lankao, 2015

Recent assessment reports, such as the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Working Group II Report, note that it is very likely that heat waves will occur more often and last longer and that extreme precipitation events will become more intense and frequent in many regions (IPCC, 2014a). The rise of the global mean sea level will increase the risks to coastal systems and low-lying areas (IPCC, 2014a). These impacts will have direct effects on cities. It is projected with *very high confidence*, "that climate change is to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea-level rise, and storm surges" in urban areas, especially for those "lacking essential infrastructure and services or living in exposed areas" (IPCC, 2014b).

3.2.2 Urbanization and Hazard Exposure

Urbanization and rapid or unplanned population growth lead to the concentration of population and assets in hazard-prone urban areas (Gencer 2013a). This exposure and the embedded conditions of socioeconomic, built-environment, spatial, and institutional vulnerabilities produce disaster risks when hazards occur (Gencer 2013a). Settlement patterns, urbanization, and changes in socioeconomic conditions have all influenced observed trends in exposure and vulnerability to climate extremes (Revi et al., 2014). These urban climate change risks, vulnerabilities, and impacts are increasing across the world in urban centers of all sizes, economic conditions, and site characteristics (Revi et al., 2014). However, certain regions of the world experience higher urbanization levels and more unplanned urbanization than others. These regions are not able to meet their cities' needs due to inadequate capacity, unstable governance structures, and substandard infrastructure, built-environment, and urban services. This leads to not only increased exposure, but also to urban vulnerabilities that will increase disaster risks. For instance, Latin America and the Caribbean (LAC) and Europe are currently among the most urbanized regions in the world; however, according to UN-DESA (2015), it is projected that within the next decades, African countries will face higher projected urbanization levels (see Table 3.1). Coupled with existing vulnerabilities in the region, African countries are expected to continue to experience high risk from disasters (Gencer, 2013b) (see Figure 3.2).

Scholarship on urbanization and vulnerability has focused mostly on global and national distributions of current and future exposure of urban areas to climate hazards (McGranahan et al., 2007; Balk et al., 2009). Other dimensions of urban vulnerability, such as sensitivity and capacity, have been insufficiently studied. Some scholars have explored the associations between levels and rates of urbanization of country groups with different levels of development and selected indicators of exposure, sensitivity, coping capacity, and adaptive capacity. Although country groups are at similar risks from exposure to floods, droughts, and other hazards, countries with rapid urbanization and economic growth, especially in Asia and Africa, face greater challenges with respect to higher sensitivity and lack of capacity (Garschagen and Romero-Lankao, 2015) (see Figure 3.1). These countries show significantly higher sensitivity and lower capacity than those with similar current income and urbanization levels but less dynamic urban growth.

Although the global distribution of urban risks is highly context-specific, dynamic, and uneven among and within urban areas and regions, absolute exposure to extreme events over the next few decades is projected to be concentrated in large cities and in countries with populations in low-lying coastal areas, as in many Asian nations (McGranahan et al., 2007). Indeed, as of 2010, there were 442 cities with populations of 1 million or more, and a large majority of them are located in low- and middle-income nations and in hazard-prone areas particularly in Africa, Asia, and Latin America, a trend that is expected to continue within the next decade (Gencer, 2013a).

The geographic location of cities makes them susceptible to certain climate hazards. Among the most challenging risks of climate change are the effects of sea level rise on coastal cities that may have critical infrastructure and large settlement areas in

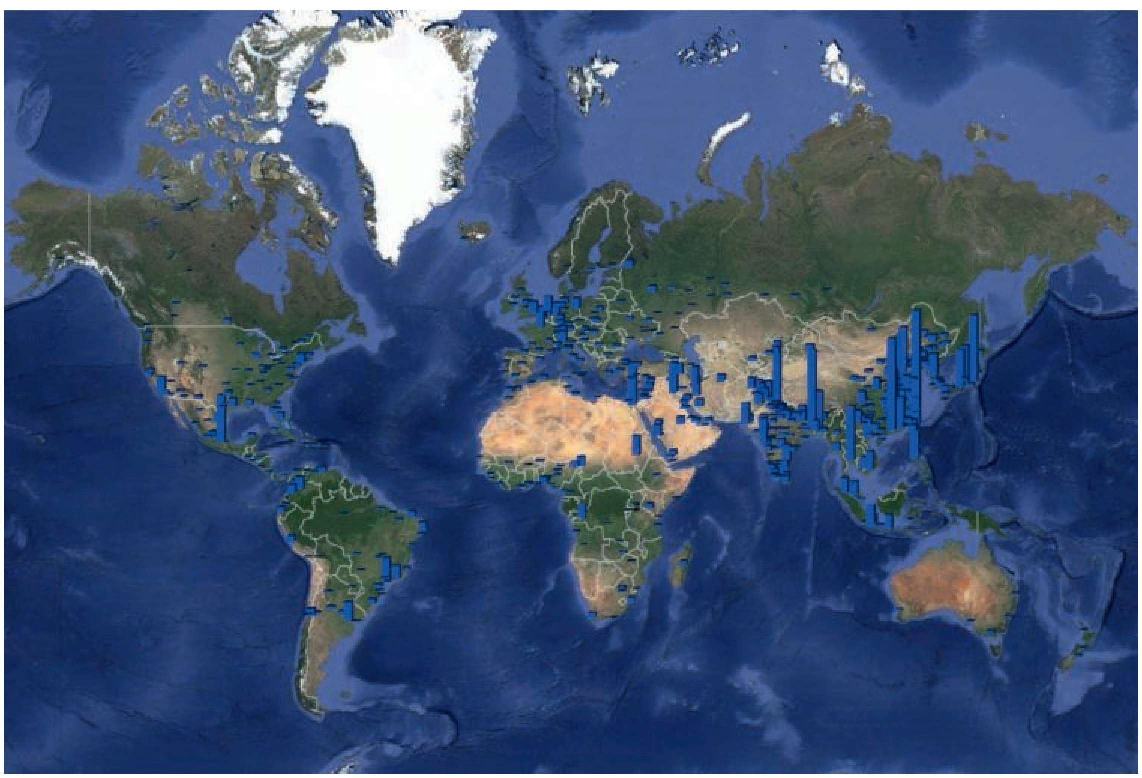


Figure 3.2 *Metropolitan populations exposed to river flooding, according to Swiss Re's* Mind the Risk *(2013). Longer bars represent larger populations.*

Source: Swiss-Re (www.swissre.com/catnet)

Figure 3.3 *Damaged homes in Midland Beach, Staten Island as a result of Hurricane Sandy, October 2012.*

Photo: Somayya Ali Ibrahim

the most low-lying areas (see Chapter 9, Coastal Zones). Sixty-five percent of the world's urban population currently lives in coastal locations, and this percentage is expected to increase to 74% by 2025 (UN-Habitat, 2011; Gencer 2013a). Most megacities are either located on seacoasts or directly linked with rivers, thus increasing exposure in their hazard-prone areas (Gencer, 2013a). Coastal flooding, beach erosion and saltwater intrusion, river sedimentation, flooding, and landslides are some of the potential hazards than can affect coastal areas and cities built near rivers in all regions of the world (Wang et al., 2014; Stewart et al., 2014). Some cities, such as Santiago, Mexico City, Bogota, and Rio de Janeiro, are also located in geographical regions that are prone to landslides as a result of high climatic rainfall and rapidly changing terrain.

The New York Metropolitan Area offers an example of the importance of geographic location. In *A Stronger More Resilient New York*, the New York City Panel on Climate Change estimated that, sea level rise in the metropolitan region could reach 30 inches above present day by the 2050s (City of New York, 2013; NPCC, 2015). Swiss Re estimated the annual average loss from tropical cyclones in the city to increase from US$1.7 billion to US$4.4 billion by the 2050s due to climate change alone if resiliency measures are not implemented. A storm that causes an economic loss comparable to Hurricane Sandy is projected to increase in frequency, having a return period of 50 years by the 2050s (NPCC, 2015). Neighborhoods in New York vary in elevation and proximity to the coast, and therefore the vulnerability of the built environment changes across this urban landscape (NPCC, 2015). The Rockaway Peninsula in Queens and Midland Beach in Staten Island are two particularly exposed residential neighborhoods. Both felt the brunt of severe structural damage when Hurricane Sandy came ashore, despite its having been downgraded to a tropical storm by the time it made landfall. Widespread beach erosion, flooding, and boardwalk damage occurred there, while homes and subway lines were inundated with floodwaters. Figure 3.3 shows the destructive power that the storm imposed on households in coastal neighborhoods.

Lower Manhattan was also critically impacted by the storm surge, affecting transportation hubs, electricity distribution, and businesses. At the time of the storm, climate risks were not fully incorporated into major infrastructure projects like the US$530 million construction of the South Ferry subway station from 2005 to 2009, which was not flood-proof despite being in a high-risk flood zone (Rosenzweig and Solecki, 2014). As a result, the subway station was one of the most critically impacted stations throughout the system, experiencing a 14.1-foot storm surge and severe flood damage (see Figure 3.4).

Likewise, storm surges from typhoons and their impacts are expected to worsen due to rising sea level in the Philippine Sea at an increasing rate of 12 millimeters annually. One of the strongest tropical cyclones on record, Typhoon Haiyan, made landfall in November 2013 and caused estimated economic damages between US$6.5 billion and US$14.5 billion. Only a small percentage of this damage (US$300 million–700 million) was covered by private insurance (AIR Worldwide, 2013). Typhoon Haiyan did not strike the most populated area of the Philippines; however, it is predicted that if the storm had struck Manila, losses would have been significantly higher.

In addition to coastal flooding and storms, cities are also expected to be affected by severe heat events. Extreme cold

Figure 3.4 *Aftermath of the flood damage to South Ferry station, October 2012.*

Photo: Somayya Ali Ibrahim

events could lead to increased use of energy and worsening air pollution conditions, whereas expected heat waves could worsen in cities with pronounced urban heat islands (UHIs) due to the heating up of the concrete buildings and paved areas[1] (see Chapter 2, Urban Climate Science, and Chapter 12, Urban Energy). Indeed, many cities in Europe were highly affected by heat waves in the past two decades, leading to deaths as well as to high monetary costs due to the impact on agricultural crops. The 2010 heat wave in Russia caused more than 50,000 deaths and resulted in US$400 billion in economic damages.[2] It also resulted in higher prices for specific food commodities such as wheat for a period of several months. A large proportion of the deaths occurred in Moscow and other larger cities in the region. According to the projections of the IPCC, heat waves and droughts are expected to continue to impact particularly the cities of Southern Europe through negative consequences in agriculture and water supply and other sectors such as tourism and health and massive forest fires endangering the peripheries of urban areas (Gencer, 2014).

Changes in water availability and in the intensity and frequency of floods and droughts (see Table 3.1) will have profound consequences for cities in terms of both water resources and water management systems (see Chapter 14, Urban Water Systems). Santiago, Chile, illustrates this. The city is located within the Maipo Basin, a watershed supplied by Andean mountain glaciers and their associated snowmelt (Melo et al., 2010). The water provided by these glaciers feeds nearly the entire urban water supply, supplying 90% of potable drinking water, and the built environment in Santiago was constructed to catch this runoff for municipal water demands (Melo et al., 2010). The functioning of the region's economy depends on water being fed to this infrastructure network on a regular basis. However, climate change is predicted to increase temperatures as well as decrease precipitation in this region of the globe (Magrin et al., 2014). This poses several threats of floods, landslides, and droughts as a result of changes in the hydrological cycle that includes the glacial and snowmelt water supply to this catchment area. It is predicted that over the coming century, water availability fed by Andean glaciers will diminish by roughly 40%, while simultaneously the urban population grows from 6 million to more than 8 million by 2030 (Barton and Heinrichs, 2011; Ebert et al., 2010).

Climate and environmental hazards result not only from long-term anthropogenic GHG-driven climate change but are also driven by regional changes (e.g., in land use and water demands) induced by urbanization. Land use changes will in turn escalate the risks of short-term disaster events such as flooding and landslides in neighborhoods of Santiago due to increased exposure of residents to water runoff after rain events (Ebert et al., 2010). There has been growing evidence of these flood risks over the past two decades. For example, in May 2008, severe floods and subsequent landslides forced 13,000 Santiago residents from their homes. The rising population of these neighborhoods in proximity to rivers will continue to present new and challenging flood disaster risks over the coming decades (Ebert et al., 2010). While city planners will need to use the best available science about projected water supply levels as well as future flood risks in their long-term decision-making, they are only starting to incorporate climate into their policies and actions (Romero-Lankao et al., 2014) (see Chapter 16, Governance and Policy).

Urbanization and economic growth coupled with the impacts of climate change is likely to greatly increase the impacts of disasters in urban areas in the future. Climate change is expected not only to alter the intensity and the frequency of hazards, but also to increase the vulnerability of urban populations and places by affecting exposure patterns of settlements (Gencer 2013a). Additionally, economic growth and uncontrolled urbanization

1 Munich Re Group (2005). *Megacities – Megarisks: Trends and Challenges for Insurance and Risk Management*. Munich Re Group Knowledge Series. Accessed November 2, 2014: http:www.munichre.com (2006):25; in Gencer, 2013a.

2 According to EM-DAT Figures, http://www.emdat.be/country_profile/index.html

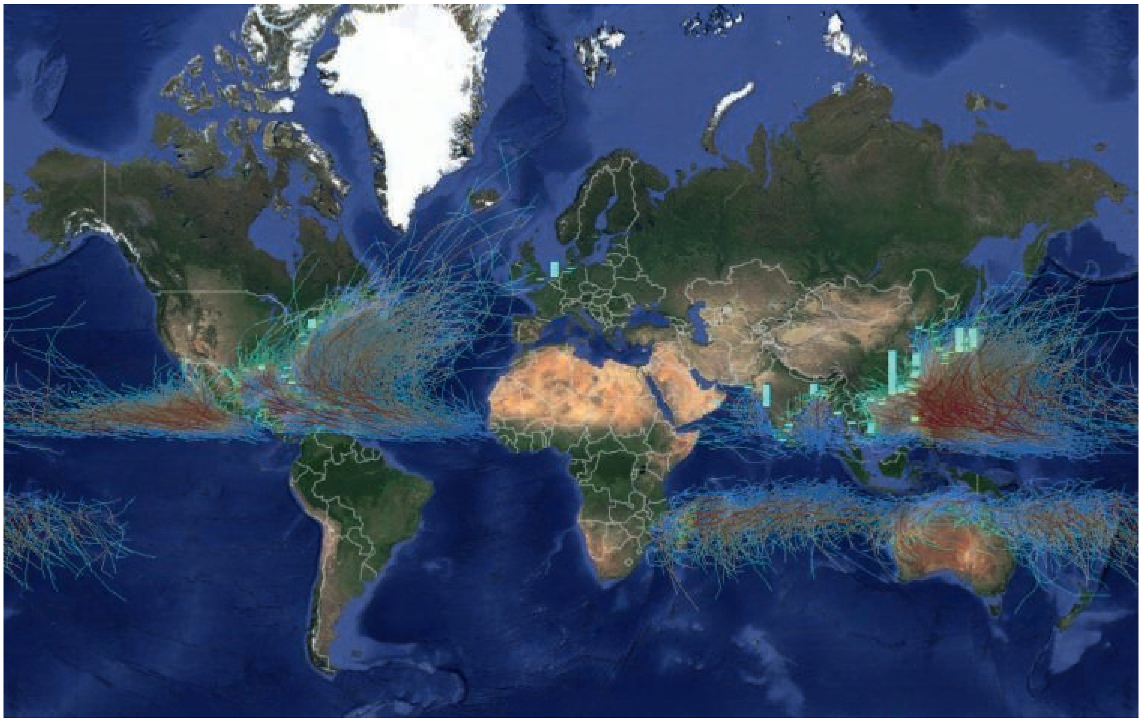


Figure 3.5 *Metropolitan populations exposed to storm surge, overlaid with the historical hurricane storm tracks from 1851 to 2012, according to Swiss Re's* Mind the Risk *(2013). Longer bars represent larger populations.*

Source: Swiss Re (www.swissre.com/catnet)

will add to the exposure and vulnerability of urban areas, which are inherently complex, thus requiring a new framework for decision-making for DRR, CCA, and resilience building.

3.3 Urban Risk and Vulnerability

Urban risk is not only determined by hazard and exposure but also by vulnerability, which is shaped by many factors including the cultural and economic characteristics of urban residents (see Chapter 6, Equity and Environmental Justice); level of technical and institutional capacity of city governments; built environment and infrastructure; quality of ecosystem services; and the threats from human-induced, interconnected stresses and actions such as resource overexploitation and environmental degradation of areas providing natural resources and services. This section analyzes these components and then presents a new decision-making framework that captures the complex and systemic nature of vulnerability in urban areas and recognizes the dynamics of urban risk and the influence of multiple stakeholders in urban systems.

Urban risk can be defined as the likelihood of occurrence of a hazard; the possibility of loss, injury, and other impacts; or the probability of the occurrence of an adverse event and the probable magnitude of its consequences. Risk scholarship has focused on how changes in an environmental hazard or combination of hazards (e.g., temperature extremes, air pollution, and precipitation extremes) relate to such outcomes (risk proxies) as mortality, morbidity, and economic damage and on how sociodemographic, built environment, and institutional factors (e.g., age and gender, quality housing, and effective response systems) mediate the relationship between the urban hazard and risk (O'Brien et al., 2007; Romero-Lankao and Qin, 2011).

Studies on urban vulnerability tend to portray it as the degree to which a city, population, infrastructure, or economic sector (i.e., a system of concern) is susceptible to and unable to cope with the adverse effects of hazards or stresses, such as heat waves, storms, and political instability (Revi et al., 2014; Romero-Lankao et al., 2012). Urban vulnerability is a relational concept that captures a complex and dynamic reality. In addition to referring to the possibility that a system may be negatively affected by a hazard or stress, it is also a relative property defining both the sensitivity and the capacity to cope with that stressor. Therefore, vulnerability cannot be defined by the hazard alone, nor can it be represented strictly by internal properties of the system being stressed. Instead, it must be looked at as an interaction of these factors (Romero-Lankao and Qin, 2011).

The concepts, research questions, dimensions, and indicators of urban vulnerability and risk can be grouped into three lineages: *vulnerability as impact* (the most commonly applied approach), *inherent or contextual vulnerability*, and *urban* *resilience* (O'Brien et al., 2007; Romero-Lankao et al., 2012). Urban vulnerability is shaped by physical, demographic, economic, and environmental factors or processes that affect the differential susceptibility of urban households, neighborhoods, and communities – the focus of concern – to the impact of climate hazards.

3.3.1 Socioeconomic Inequality

Common to urban vulnerability research and policy intervention is the concern that differentiated capacities of urban populations to respond to heat waves, floods, and other hazards depend on differences in socioeconomic status (see Chapter 6, Equity and Environmental Justice). Urban population vulnerability springs from social inequality; in other words, from differential access to land property rights, education, income, employment, infrastructure, housing, and political power and from weak, ineffective, or lacking social security, planning, and early warning systems (Harlan et al., 2007; Gencer, 2008; Romero-Lankao et al., 2014).

The strong tie between vulnerability and social inequality in cities starts with the legacies of past decisions and policies around urban land use planning and access to sanitation, water, and other infrastructures and services. Particularly in developing countries, it includes some mechanisms of social exclusion such as formal and informal divisions of the ordered and spontaneous parts of a city (Romero-Lankao et al., 2014). In many informal settlements and peripheral municipalities insecure land titles add to the vulnerability of urban residents. These lead to the social fragility and difficult disaster recovery for these settlers, who can neither obtain government aid nor credit with their illegal titles (Gencer 2013a). Social exclusion, ethnic or immigrant status, poor education, and limited job opportunities add to the income poverty of these residents, limiting their mobility and ability to resettle and creating one of the biggest challenges for urban policy-making in the developing world.

These mechanisms of exclusion result in differentiated patterns of location, access to resources, rights, assets, infrastructures, and services, some of which define urban populations' resilience. Social inequality is not equal to social vulnerability, however, because vulnerability is a relational concept. At the microlevel, it is not only location in hazard-prone places or individual characteristics such as age, gender, and existing medical conditions that can make populations sensitive, but also the material and symbolic sources of assets, capital, or resources that can enhance population resilience, such as education, income, house quality, infrastructure and services, legal status, and social capital (e.g., participation in networks and family support) (Romero-Lankao et al., 2014). Of no less importance are city-wide disaster management and adaptation policies.

3.3.2 Physical Processes

The urban built environment is susceptible to climate extremes such as heat waves, floods, and other climate hazards as a result of physical location conditions and the performance of buildings and critical infrastructure. Implementation of up-to-date building standards and good urban planning actions can help manage or reduce disaster risks (Gencer, 2008; Solecki et al., 2011). However, many cities do not have standard design, building, and land-use regulations available; do not implement them due to a powerful construction and development sector; or corrupt development and building control practices.

In many instances, this phenomenon is observed in high-income residential construction that disregards planning decisions and the protection of ecosystems in order to secure locations in scenic areas such as close to water basins or in protected forest areas. Many examples of this practice are observed in gated complexes in Istanbul, on the fertile slopes of Mount Vesuvius in Naples, or in Mexico City (Gencer 2013a).

Box 3.1 Disasters and Social Vulnerability Index

Claudia Natenzon and Ricardo Castro

University of Buenos Aires

A disasters social vulnerability index (DSVI) was developed by the Natural Resources and Environment Research Program, University of Buenos Aires (Natenzon and González, 2010). It is a quantitative, statistical evaluation that allows researchers to identify different degrees of social vulnerability in administrative units. The usefulness of such an index is that it provides a primary evaluation of the heterogeneities in the geographic distribution of social vulnerability. The DSVI is composed of indicators that are grouped into three subsets: demography, living standards, and economic capacity. The index allows one to distinguish the importance of the different aspects considered. The selected indicators thus aid in prioritizing interventions and are derived from publicly available data on social, demographic, and basic economic characteristics.

Such indicators are based on variables listed in the three dimensions (Vazquez-Brust et al., 2012): (1) demographic (e.g., dependent population and single-parent homes), (2) living standards (e.g., overcrowded housing, supply of drinking water, and sewage services), and (3) economic capacity (e.g., health, literacy/education, and work/employment status).

Figure 3.6 *Gated settlements in Istanbul's previously protected forest areas.*

Photo: Ebru Gencer, 2005

In other instances, corruption or shortcomings during construction increase risk from natural hazards. In Florida, investigations after the 1992 Hurricane Andrew found major shortcomings in construction techniques and code enforcement (Mileti, 1999). Mileti (1999) reported that in Southern Dade County, homes built after 1980 suffered more damages than pre-1980 constructions, including loss of roof materials that also led to damage to other buildings and cars (Gencer, 2008; Gencer, 2013a). According to Mileti, a review of the county's Board of Rules and Appeals found a number of instances in which changes were made under pressure from builders for construction cost savings such as allowing the use of staples instead of nails to install roofs.

Physical susceptibility to hazards that are heightened by climate change is most evident in the rapid expansion of urban areas and the creation of unplanned informal settlements (see Chapter 11, Housing and Informal Settlements). The increase of the urban poor and their exclusion from formal housing sectors result in growing informal settlements that create immense challenges in disaster risk management (DRM) for climate change (Gencer 2008; Gencer 2013a). Most informal settlements display physical vulnerabilities due to their location or construction practices because they are often located on land not deemed appropriate for habitation because of its steep terrain or geographical characteristics that make these areas prone to subsidence, landslides, or mudslides (UN-Habitat, 2003; Gencer 2013a). For instance, in the Caribbean nation of Belize, where the slum population is equal to nearly half of the urban population, the low-lying coastline accommodates approximately 45% of its total population in densely populated urban areas such as Belize City (approximately 20.5% of total population), and these coastal centers represent some of the country's areas most vulnerable to storm events because they lie approximately 1–2 feet below sea level (WB and GFDRR, 2010; Gencer, 2013b).

The informal status of urban populations exerts a profound influence on both hazard exposure and capacity. Informality is a state of regulatory flux, where land ownership, land use and purpose, access to livelihood options, job security, and social security cannot be fixed or mapped according to any prearranged sets of laws, planning instruments, or regulations (Romero-Lankao et al., 2014). This condition leads to an ever-shifting relationship between the legal and the illegal, the legitimate and the illegitimate, the authorized and the unauthorized. Informality becomes the site of considerable power, where some forms of growth in risk-prone areas enjoy state sanctions while others are criminalized. For the latter, informal status becomes a systemic determinant of lack of access to assets and options for adaptation capacity. Conversely, the "regular," "legal," or "formal" status of a settlement gives security from eviction, becomes an incentive to invest in more structural adaptation actions (e.g., housing improvements to effectively respond to floods), is a requirement for infrastructure and service provision, and helps avoid the stigmatization that disempowers informal neighborhoods.

Many times, inadequate building materials accompany risk of physical exposure in squatter settlements because structures are often built with impermanent materials such as earthen floors,

Figure 3.7 *Use of non-resilient materials in hurricane-prone Jamaica.*

Photo: Ebru Gencer, 2012

mud-and-wattle walls, or straw roofs (UN-Habitat, 2003) (see Chapter 11, Housing and Informal Settlements). In many cases, these settlements lack municipal services and infrastructure, resulting in further disasters, such as waste disposal in riverbeds and ravines as well as the urbanization of watersheds and wetlands that leads to floods from heavy rainfall, as observed in the informal settlements of the Western tBalkans (Gencer, 2014). In addition, lack or inefficiency of public urban services and institutions – transportation networks, hospitals, fire and police stations – translates into lack of response capacities at times of disaster, thus further exacerbating vulnerability and disaster risk for these urban settlers (Gencer, 2008, Gencer 2013a).

Other factors that contribute to physical vulnerability include the type of terrain where structures are built, such as the soil quality, geomorphology, and surface and groundwater features of the landscape (Blanco et al., 2011). Additionally, the political and legal framework pertaining to land use further contributes to the risks that the built environment faces, including land-use planning practices, zoning codes, and legal rights to property ownership.

3.3.3 Institutional Processes

Institutional dynamics play a central role in urban vulnerability and risk. Vulnerability and risk may be amplified due to organizational constraints and exclusion of multiple stakeholders in urban governance (see Chapter 16, Governance and Policy). Several characteristics of ineffective or capacity-lacking institutions involved in DRM may include (Natenzon, 2005):

- Obstacles such as political distrust, lack of communication (e.g., unawareness of what other agencies are doing), and lack of coordination.
- Inability to scale up successful programs and projects that may be dismissed due to government changes
- Inadequate means or ways to communicate risks and disasters to urban populations.
- Corruption in the policy-making and implementation process (see Chapter 16, Governance and Policy). Corruption affects the confidence of urban citizens in their institutions and destabilizes the society.

Fragmentation of policies and actions increases social vulnerability and generates a high degree of uncertainty that can affect the capacities of cities to respond to disasters. Poor institutions and policies are not adequate to confront long-term processes. Nevertheless, cultural norms and traditions of urban residents who experience increased vulnerability can play a positive role in risk reduction. Identification with place, and previous experience with local danger may invigorate vulnerable urban residents to establish local strategies such as applying traditional house-building techniques to reduce risk or establish neighborhood networks, such as voluntary organizations for risk communication, preparedness, or recovery. Recognition of these conditions can open the door to participatory governance, greater public involvement, and greater autonomous risk management.

3.3.4 Ecosystem Services and Environmental Processes

Urbanization is not only related to increased levels of GHG emissions, but also exerts pressure on ecosystems surrounding cities, increasing environmental vulnerability to hazards and climate change (see Chapter 8, Urban Ecosystems). Urbanization is a key driver of land fragmentation and loss of biodiversity (Grimm et al., 2008). Differences in land quality, land use, and functional characteristics determine urban vulnerability and risk in different and not yet fully understood ways. For instance, changes in vegetation cover are one of the factors influencing the risk of floods, rainfall-triggered landslides, and wildfires near or in urban centers (Braimoh and Onishi, 2007; Smyth and Royle,

Box 3.2 Management of Slope Stability in Communities

One particularly useful example for housing and shelter comes from an innovative methodology for assessing and reducing landslide risk in unplanned urban communities (see Chapter 11, Housing and Informal Settlements). Management of Slope Stability in Communities (MoSSaiC) is "based on identifying the localized physical causes of landslides (often related to inadequate drainage), designing appropriate engineering measures to address these causes (such as surface water drains), and constructing those measures to an adequate specification so that the root cause of the landslides is effectively addressed. This science- and engineering-based approach is embedded in community participation and the engagement of city government experts, policy-makers, and development agencies. It has been successfully applied in 12 communities in the Eastern Caribbean with funding from national governments, UNDP, USAID, and the World Bank." Improved, resilient housing is important because most housing is renewed at periods of 30 years or less (particularly in developing countries), and designs that address landslide hazards can make a substantial contribution.

2000). Changes in land use may cause changes in land surface physical characteristics (e.g., surface albedo) that have implications for water-related hazards such as droughts and floods because precipitation can be enhanced or reduced depending on climate regime, geographic location, and regional patterns of land, energy, and water use (Romero-Lankao et al., 2014).

Urban areas are key drivers of changes in carbon, water, and other biogeochemical cycles, but they are also vulnerable to extreme temperatures, air pollution, water degradation, and other hazard risks associated with these changes (Pataki et al., 2006). High levels of air pollution are known to increase the risks of negative health impacts on human populations, particularly when combined with adverse weather conditions (e.g., heat waves caused by climate change) (Bell et al., 2008). Health impacts from air quality and temperature changes become especially critical in rapidly growing low- and middle-income countries (Kan et al., 2008; Romero-Lankao et al., 2013; Revi et al., 2014). Climate hazards, such as floods and droughts, are another example. Increased vulnerability of urban water systems and their users can result from long-term processes such as poor construction, the inefficient operation of water infrastructure, and land use changes that increase impervious surfaces and are driven by urbanization (Romero-Lankao, 2010).

Ecosystem services of relevance to urban areas (e.g., flood protection) represent an important set of non-built assets and add value to the quality of life in urban areas. However, many environmental assets and ecosystem services are vulnerable to the changes associated with population growth, land use, and climate change. One of the greatest challenges for coastal cities is that of sea level rise and storm surge, which can cause inundation and damage to many important environmental assets such as wetlands and coastal recreational zones (see Figure 3.8).

Figure 3.8 *Coastal recreation zone in Victoria, Australia.*

Photo: Xiaoming Wang

Figure 3.9 *Buffer zone developed in the Central Coast, a peri-urban region in New South Wales, Australia.*
Photo: Xiaoming Wang

In Australia, Brisbane Water is one of the most heavily populated catchments in eastern New South Wales, and its environmental assets are heavily used by tourists and residents for water-based recreational activities such as boating and fishing. This area is also adjacent to a National Heritage Area of valuable wetlands that extend into Brisbane Water and provide scenic attraction, recreation, and environmental education, as well as economically valuable ecosystem goods and services (e.g., water filtration, storm surge protection, and fisheries) and tourism revenue of US$360 million per year (Harty and Cheng, 2003; Tourism Research Australia, 2007).

The coastal ecosystems in this region are already under stress from development and increasing fragmentation, and future sea level rise will have a large impact on the conservation and productive value of these coastal habitats (HCCREMS, 2010). The estuarine wetlands of mangrove and salt marsh communities are relatively rare and host a broad range of endangered and vulnerable plants and animals (Conacher Travers Pty. Ltd., 2001). They are also habitats in decline, with coastal inundation already affecting the persistence of present species (Mitchel and Adam, 1989; Mazumder et al., 2006). Lin and colleagues (2014) in a land use study of coastal communities show that a 1 meter inundation event has an annual occurrence probability of 66.7% at present, inundating 98% of the ecologically important habitat in a particularly threatened study area. This risk is expected to increase with future sea level rise and could potentially lead to the salinization and loss of habitat for freshwater or brackish ecosystems.

Protection of environmental assets presents a difficult set of adaptation decisions; the landward progression of salt marshes due to sea level rise is often restricted by the placement of roads or other hard structures that cause salt marshes to shrink or become more fragmented over time (Harty and Cheng, 2003). If present levels of urban development are to be maintained, less land will be apportioned for ecosystem habitat and migration, with present ecosystems competing for smaller areas of coastal land area. Management options to maintain ecosystems within the landscape (e.g., restoration of salt marshes or use of buffer zones) have been discussed, but can be labor intensive (Laegdsgaard, 2006) (see Figure 3.9). Therefore, the question of how and if ecosystem amenities and services should be maintained under future sea level rise scenarios becomes increasingly important.

3.4 Risk Assessment Framework and Decision-Making Process

Many concepts of DRM are based on a static comprehension of hazards and do not take into consideration the cumulative effects of climate change or the everyday risks to which urban communities are exposed (Gencer et al., 2013; Solecki et al., 2011). A new framework for disaster risk assessment and risk-based hazard management decision-making is based on a comprehensive concept encompassing the dynamics of urban development and the complexity of cities. This requires a paradigm change in urban DRM, making it a more comprehensive policy agenda that incorporates DRM and CCA agendas into a comprehensive policy and agenda for sustainable urban development (Gencer et al., 2013).

Such a paradigmatic shift is reflected in the *Special Report on Managing the Risks of Extreme Events and Disasters to Advance*

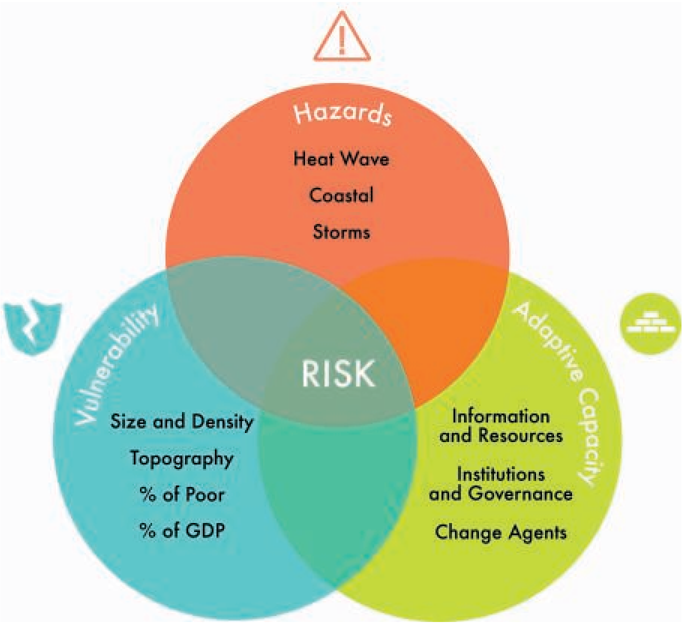


Figure 3.10 *Urban climate change vulnerability and risk assessment framework.*

Source: Mehrotra et al., 2011

Climate Change Adaptation that illustrated the significance of linking climate change adaptation with DRM and sustainable development (IPCC, 2012). The IPCC Working Group II highlighted the importance of analyzing vulnerability, risk, and adaptation as the most relevant subjects for understanding and managing climate change risks (IPCC, 2014a).

Climate change impacts, adaptation, and vulnerability assessments have been developed in different forms driven to address current and future challenges and uncertainties (Carter et al., 2007). In the Urban Climate Change Research Network (UCCRN)'s *First Urban Climate Change Research Network Assessment Report on Climate Change and Cities* (ARC3.1), an urban climate change vulnerability and risk assessment framework was introduced that was based on the interplay of hazard, vulnerability, and adaptive capacity to develop climate adaptation and disaster management (Mehrotra et al., 2011) (see Figure 3.10).

UCCRN's *Second Urban Climate Change Research Network Assessment Report on Climate Change and Cities* (ARC3.2) uses the framework of risk (R) expressed as a function of hazard (H), exposure (E), and vulnerability (V).[3] The IPCC Working Group II report (IPCC, 2014b) explains that risks from climate change impacts arise from the interactions among hazard (triggered by an event or trend related to climate change), vulnerability (susceptibility to harm), and exposure (people, assets, or ecosystems at risk).

A paradigmatic shift from single-impact hazards-focused risk assessment to system-based risk assessment is essential to identify current and future risks if we are to reduce disaster risks and make cities resilient. An understanding of the city as a system involving multiple stakeholders and institutions, composed of urban vulnerabilities – as described in Chapter 1, Pathways to Urban Transformation, and Section 3.1 – and their horizontal and vertical integration, is essential in defining risks to current and future cities.

In the risk assessment framework, it is critical to make optimally targeted decisions in developing CCA and DRR across scales that can be spatial, temporal, and institutional. In this chapter, risk-based decision-making is shifting away from the impact-centric approach (ICA) to a decision-centric approach (DCA) as described in Figure 3.12. The decision-centric risk assessment framework includes:

- An H-E-V-based risk assessment that takes into account the hazards caused by climate change and variability to estimate risk distribution in terms of socioeconomic, environmental, institutional, and physical loss (or opportunity) faced by cities. Future city outlooks (e.g., population growth, demographic changes, land use change) and subsequent exposure and vulnerability to hazards are taken into account.
- Development of climate change actions and DRR options involving policies, planning, and local actions through both horizontal and vertical integration (at multiple scales of spatial, temporal, institutional aspects) to reduce exposure and/or vulnerability of socioeconomic, environmental, institutional, and physical aspects and eventually lead to the reduction of risks to cities.
- Understanding of the balance of avoided loss and additional benefit – with opportunity loss in adaptation and residual loss after adaptation – to optimize the selection of better options, which is also a dynamic, time-dependent, and iterative process.

The impact-centric approach to DRM and CCA decision-making for cities is considered a linear approach because it starts with an examination of the climate hazards to cities and then takes into account vulnerability to hazards by integrating the knowledge of existing city capacities. Disaster risk reduction and CCA strategies are then developed by enhancing resilience and adaptive capacity to reduce the impact. However, because decisions are based on hazard-driven impact assessment, DRR and CCA development could become disconnected from other parallel priorities (e.g., poverty reduction and sustainable livelihoods, environmental conservation, and economic development) and also from municipal and national needs. In addition, differing DRR and CCA strategies could be developed from different perspectives based on different interpretations of the impacts for different agendas, leading to ineffective results due to narrow views on DRM and CCA.

In contrast, the DCA leads to vision-driven urban DRM and CCA. Decisions aim to reduce hazard exposure in line with a future city vision, nurture resilience of cities for the potential impacts of hazards, build capacities to reduce the vulnerability of stakeholders, and establish governance that ensures

3 As explained by the equation: $R = H \times E \times V$, where all are time-dependent and spatially random variables and described by probability distribution functions.

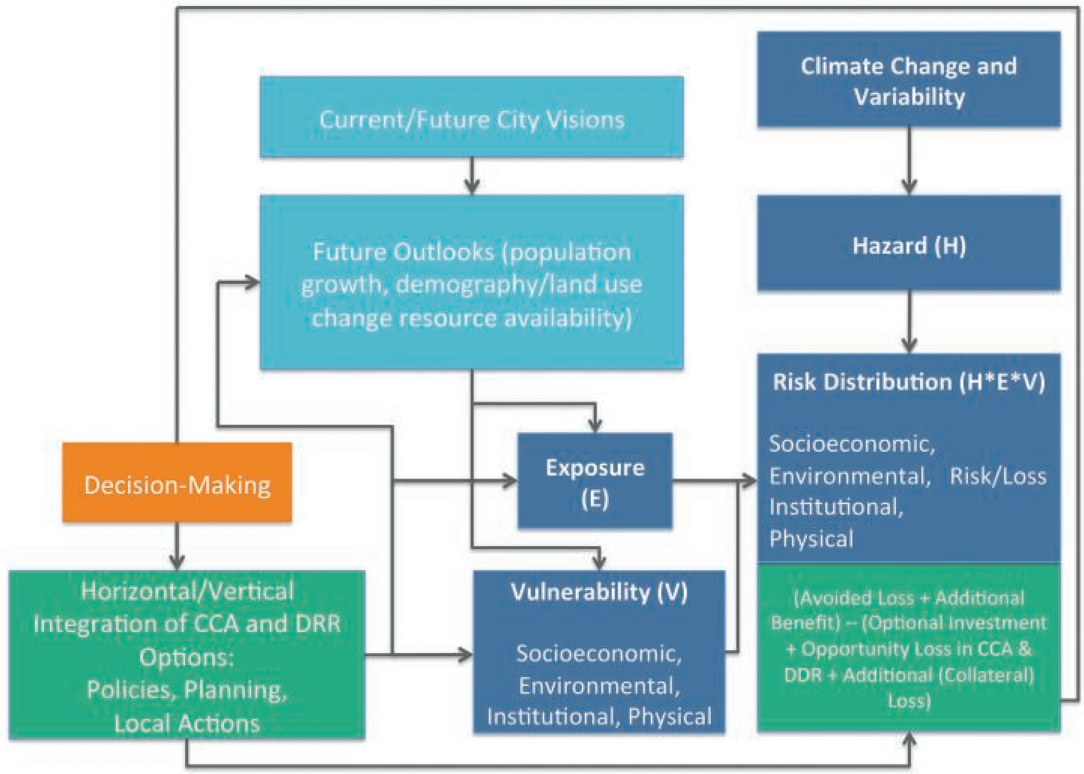


Figure 3.11 *Risk Assessment Framework, developed for UCCRN ARC3.2.*

Source: Xiaoming Wang and Ebru Gencer, 2014

resilience-building and capacity development to enable stakeholders' visions and goals. Ultimately, DCA aims to implement the visions and goals of future cities by minimizing risks of disaster and climate change impacts by taking transformative steps, in contrast to ICA that aims to reduce impacts in relation to specific disaster and climate change hazards.

3.4.1 Disaster Risk Reduction Policy Domains and the Movement toward Transformation

Opportunities for disaster risk management can contribute to the overarching aims of climate change adaptation as well as the larger goal of urban sustainable development. Much current DRR is focused on the enhancement of resiliency and flexibility to extreme events. Implicit or explicit in urban DRM are other risk management regimes including resistance (planning for stability), transformation (planning for fundamental change), and even collapse (no planning/failure to implement planning) (Solecki et al., 2017).

Many cities employ DRR policies focused on resistance. A resistance-focused DRR policy is oriented toward deploying risk management to achieve stability in underlying development. This may require major shifts and investment in nonprioritized or external elements so that resistance in one system may require collapse or transformation in another. For example, the construction of increasingly larger and more complex coastal defenses to prevent any change in function, value, or appearance of coastal land may transform near-shore ecology and livelihoods or downstream hazards. Resistant systems may expend considerable resources on preventing change by attempting to manage the external environment. Resistance and resilience have similar qualities but different intentions.

A resilient system is able to adjust flexibly in the anticipation or experience of a hazard. A resilient system's functions and core aims are maintained with only slight adjustment, although these adjustments may be significant for subsystems or over time. In social systems, an example is adjustment to insurance regimes that allow continued habitation in places of risk through changes in payment rates. In contrast to resistant systems, resilient systems can anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner through preservation, restoration, or improvement of the system's essential basic structures and functions. Essentially, the system responds by accepting loss and returning to its pre-shock/stress state, which in turn may be perceived by dominant actors as the preferred state.

A transformative regime identifies the need for fundamental change in underlying development if unacceptable risk and future loss are to be avoided. This can include distributional as well as total loss concerns. Including transformation opens new policy options once resilience meets its limits (Pelling et al., 2015). Transformation can also target the root drivers of unmet

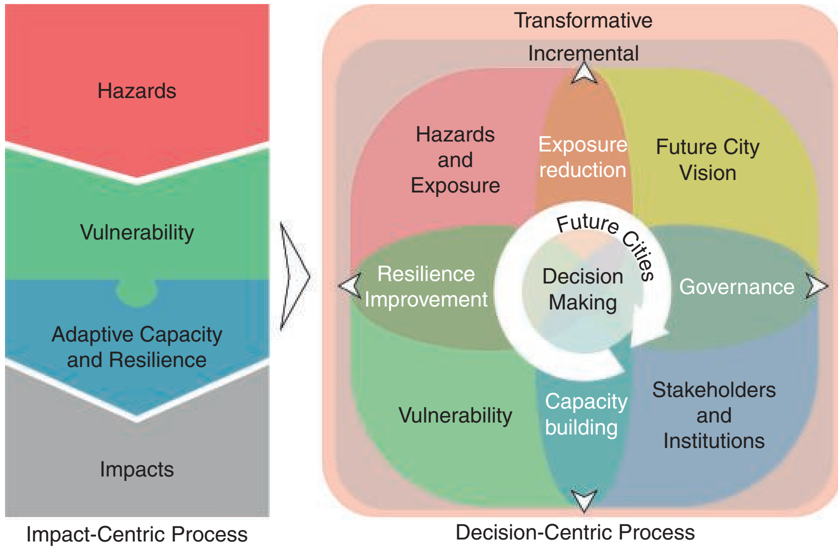


Figure 3.12 *Evolving impact-centric approach to decision-centric approach for urban vulnerability and risk assessment developed for UCCRN ARC3.2.*

Source: Xiaoming Wang and Ebru Gencer, 2014; adapted from Xiaoming Wang, 2014

sustainable development needs where these constrain adaptive capacity and action (Marshall et al., 2012). Intentional transformation of one system or object can allow the maintenance of systems at other scales (e.g., relocation of households exposed to risk will be transformative for households involved, for places of origin and destination, and may require legislative change). At the same time, relocation may help maintain resilience or resistance in wider political and economic or social systems.

City planners, risk managers, and stakeholders need to have transformation presented as an option within the range of policy domains (Solecki et al., 2017). Risk managers should address the extent to which the current policy conditions enable or fail to enable a pathway toward transformative sustainability and should consider the barriers and bridges of a transition to meaningful CCA and mitigation and enhanced sustainability. An overall premise of ARC3.2 is that fundamental transformational changes in risk management regimes are needed, given the gap between current urbanization trajectories, accelerating climate change, and the goals of sustainable development.

The ARC3.2 takes the position that transformation can occur within the contexts of multi-layered systems, formal and informal politics, and structural limits on the local action and agency of individuals and specific organizations. The requirements of urban sustainability and transformative adaptation have become linked to a series of preconditions and pathways through which people, communities, and places can move toward greater sustainability (Pelling et al., 2015; Folke et al., 2010). Although the concept of disaster resiliency holds significant theoretical and practical appeal in sustainability pathways, many argue that it does not fully explain or enable larger-scale changes within institutions and society needed to enhance the opportunities for genuine movement toward sustainability (Kates et al., 2012). This category of larger or more profound shifts is associated with the concept of transformation (see Chapter 1, Pathways to Urban Transformation) (Bahadur and Tanner, 2014; Olsson et al., 2014). Resiliency and transformation approaches are increasingly being compared and illustrated via examples and future prospects (Pelling et al., 2015).

3.5 Urban Planning and Land-Use Tools

The Decision-Centric Approach is multidisciplinary in nature, recognizing the importance of links among climate change, hazards, and the wider environment (Lewis, 1999; Wisner et al., 2004; Tran and Shaw, 2007). Identification of a hazard and assessment of risks lay the basis of potential DCA strategies, which are shaped by social and cultural influences as well as by legal, institutional, and economic constraints (Gencer, 2008). City governments are usually the immediate responsible actors that undertake DRR and resilience-building activities in urban areas. There are several strategies that can help reduce disaster risks and increase resilience in urban areas. Some of the most used strategies are institutional organization and capacity development by city governments; urban planning and development actions; building codes and engineering practices, such as infrastructure retrofitting and investment; social capacity development; public awareness and education; financial capacity development, such as insurance and incentives; ecosystem services; early warning systems; and post-disaster recovery and planning. This section explores some of these planning strategies in detail.

Urban planning is a continuous process of foreseeing, anticipating, and preparing for the future. In order to manage such change in physical geographies, urban planning makes arrangements for future demands on the use of public and private land and seeks a balance among interests "to resolve conflicting demands on space" (ISOCARP, 2005; Gencer, 2008) (see Chapter 5, Urban Planning and Design). Urban planning

Box 3.3 Sendai Framework for Disaster Risk Reduction and the UNISDR Making Cities Resilient Campaign

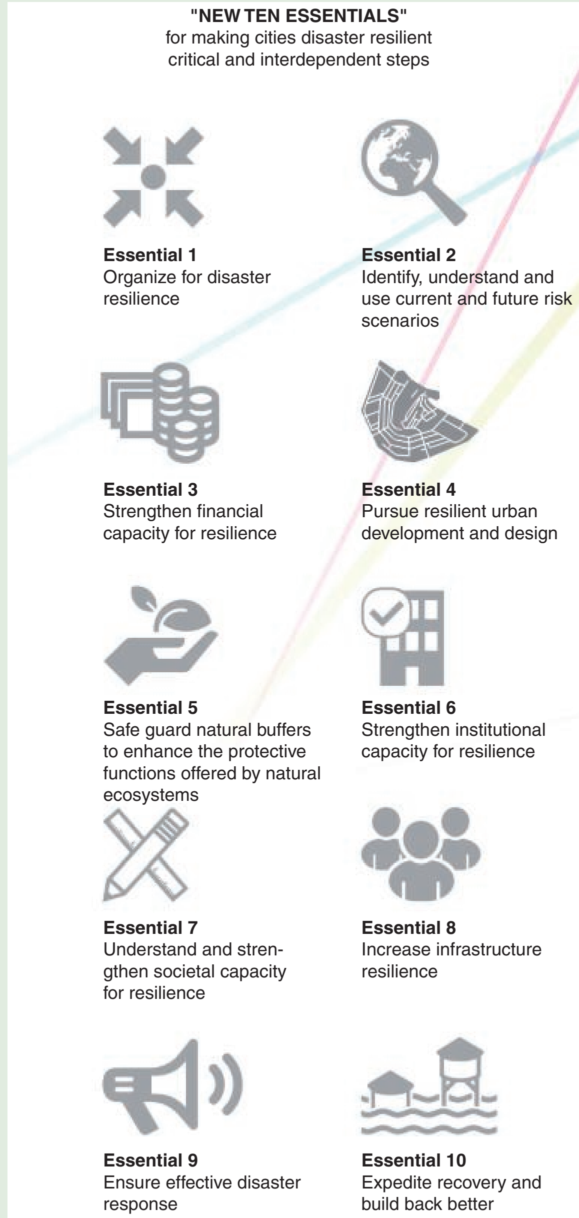
Abhilash Panda

UNISDR, Geneva

In March 2015, representatives from 187 United Nations Member States adopted the first major agreement of the Post-2015 development agenda, the Sendai Framework for Disaster Risk Reduction (SFDRR). This builds on its predecessor, the Hyogo Framework for Action (HFA), and articulates seven targets and four priorities for action. (For further information, see UN, 2015.) Policy-makers will now need to reassess the significance of resilience-building in cities as they implement the SFDRR. To support the implementation of SFDRR and the more than 2,500 cities in the UNISDR Making Cities Resilient program, a group of city and expert partners in urban resilience, including the UCCRN, have now proposed a set of New Ten Essentials. The proposed New Ten Essentials build on the previous Ten Essentials, are linked with the priorities for action of the SFDRR, and represent a transition to implementation. The primary objective is to be operational, adaptive, and applicable to all and encourage cities to implement disaster risk reduction (DRR).

The New Ten Essentials offer a comprehensive approach to DRR because they undertake to cover the most important issues for cities to become more resilient (see Box 3.3 Figure 1): Essentials 1–3 cover governance, risk science, and financial issues; Essentials 4–8 cover the many dimensions of planning, capacity, and growth; and Essentials 9–10 cover post-event recovery and building back better.

The intention of the New Ten Essentials is to enable cities to establish a baseline measurement of their current level of disaster resilience, identify priorities for investment and action, and track their progress in improving their disaster resilience over time. The New Ten Essentials intend to guide cities toward optimal disaster resilience and challenge complacency. This demanding standard reminds cities that there is *always* more that could be done and to establish investment goals (of both time and effort) for achievement over a period of years.



Box 3.3 Figure 1 *The New Ten Essentials for Making Cities Resilient.*

can help to protect environmentally sensitive areas and reduce disaster vulnerability and risks by employing land-use zoning and implementing development actions. These efforts can increase resilience by upgrading and retrofitting poorly planned settlements, especially through a participatory process that can ensure implementation and sustainability (UPAG, 2015). Olhansky and Kartez (1998) in the Second Natural Hazard Assessment study in the United States identified land-use management tools to guide development in hazard-prone areas. These and other tools include (Olhansky and Kartez, 1998; Gencer, 2008; Rosenzweig et al., 2011) (see Chapter 5, Urban Planning and Design):

- *Building standards*, such as building codes, flood-proofing requirements, seismic design standards, and retrofit requirements for existing buildings;
- *Development regulations* including zoning and subdivision ordinances such as flood-zone regulations; setbacks from faults, steep slopes, and coastal erosion areas; and zoning standards for sensitive lands (e.g., wetlands, dunes, and hillsides);
- *Critical public facilities* policies that require location of these facilities outside of hazard areas in order to discourage development and reduce damages;
- *Land and property acquisition* in hazardous areas through public funds and use of these properties in minimally

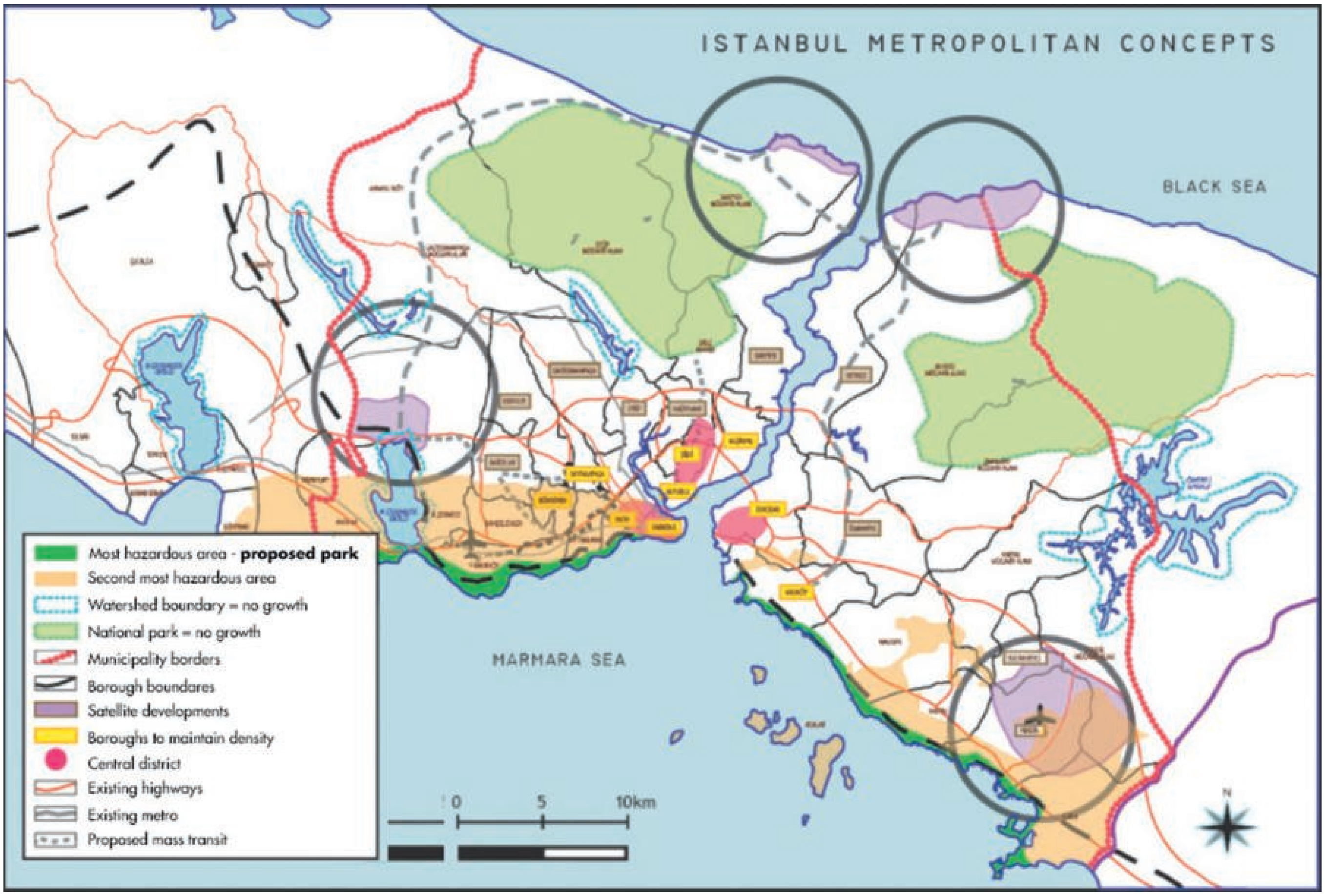


Figure 3.13 *Integrating disaster risk reduction into urban planning education in Istanbul.*

Source: S. Grava; K. Jacob, E. Gencer et al. Columbia University Urban Planning Studio: Disaster Resilient Istanbul, 2002

vulnerable ways and the acquisition of open space, recreational, or undeveloped lands for risk reduction, relocation of existing hazard area development, and acquisition of development rights;

- *Taxation and fiscal policies* to provide incentives for urban residents to reduce public costs in hazardous areas by applying regulations for safety or relocating and reducing population density in hazardous areas;
- *Information dissemination* to influence public behavior, especially of real estate customers by requiring hazard disclosure statements of real-estate sellers, providing public information by posting warning signs in high-hazard areas, and education of construction professionals.

Studies conducted in the United States examined the use of these tools by city governments and found that zoning ordinances and building standards are the most frequently used DRR tools by municipalities (Gencer, 2008; Gencer, 2013a).

In another study, the Institute for Business and Home Safety (IBHS) together with the American Planning Association (APA) and the American Institute of Certified Planners (AICP) surveyed nearly 1,500 municipal planners on Community Land-Use Evaluation for Natural Hazards (IBHS, 2002). The results of this study indicated the need for hazards planning, additional funding, support from elected officials, and technical assistance in addition to better mapping and data, states mandates for planning, and additional staff and legislative changes (Steinberg and Burby, 2002a).

However, in many developing countries, regulations, codes, standards, technical requirements, performance indicators, and best practices represent the capacity development needs of city governments and urban communities and challenges to implementation. Evaluation of the costs and benefits of specific DRR as well as climate change action alternatives can lead to the development of effective strategies aimed at exceeding minimum regulatory requirements. In addition, specific DRR/CCA requirements may be imposed by local regulations in response to site-specific hazards. Furthermore, when a change in urban land use is proposed, it must be determined whether this change triggers other risk conditions, thus requiring additional DRR and/or climate change action measures. For example,

Case Study 3.1 The Boulder Floods: A Study of Decision-Centric Resilience

Karen MacClune, Kanmani Venkateswaran

ISET-International, Boulder

Chris Allan

Pitcher Allan Associates, Boulder

Somayya Ali Ibrahim

Center for Climate Systems Research, Columbia University, New York

Keywords	Resilience, adaptation, disasters and risk, recovery, flooding
Population (Metropolitan Region)	319,372 (U.S. Census, 2015)
Area (Metropolitan Region)	1,880 km^2 (U.S. Census, 2010)
Income per capita	US$56,180 (World Bank, 2017)
Climate zone	BSk – Arid, steppe, cold (Peel et al., 2007)

On September 2013, Boulder County, Colorado received nearly a year's worth of rain in a week. Rain poured out of the Rocky Mountains onto the towns of the prairie. Creeks destroyed roads and bridges, tore out culverts and downed trees, flooded homes and businesses, and resulted in the evacuation of several towns. Boulder County and fourteen surrounding counties were declared federal disaster areas. Statewide, 1,852 homes and 203 commercial structures were destroyed and more than 18,000 people were evacuated (Colorado Division of Homeland Security and Emergency Management).[4]

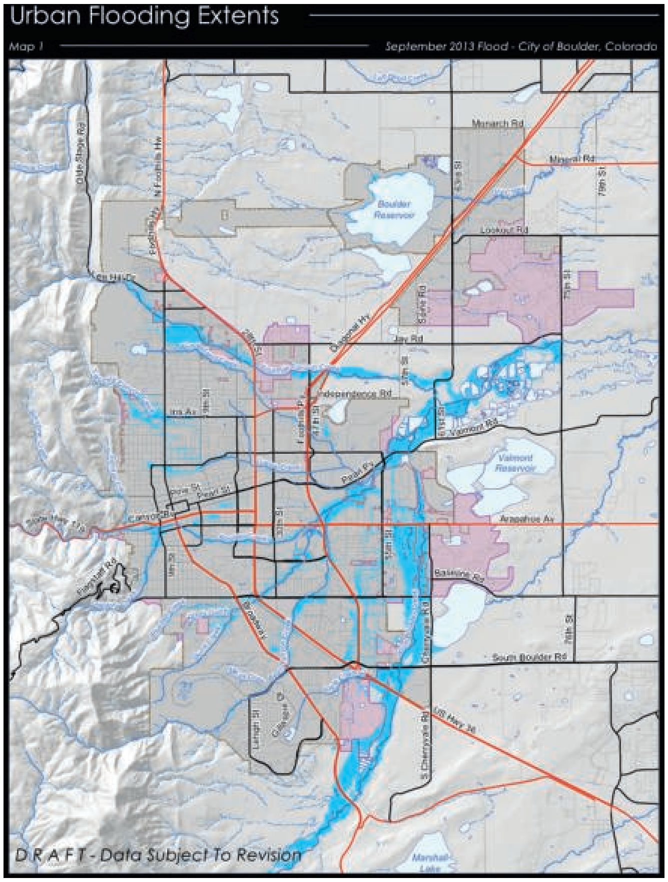
Initial analysis estimates that the total cost of the disaster exceeded US$2 billion, including $430 million to rebuild roads and bridges and $760 million to repair public infrastructure. Much of the financial loss was borne by residents – only about 1% of homeowners in the state possess flood insurance, despite the fact that the City of Boulder is considered one of Colorado's riskiest areas (City of Boulder, 2014). The City of Boulder has fifteen major drainage ways, and approximately 13% of the city is located within the regulatory 100-year floodplain, including nearly 2,600 individual structures. Flash flood risk is exacerbated by the city's downtown location, positioned at the mouth of Boulder Creek canyon, and frequent droughts and forest fires that seal off the soil, reducing its ability to absorb water.

Yet in spite of the unprecedented scale of the event, only ten lives were lost, most core infrastructure was maintained, and the response and recovery have been strong, well-coordinated, and

Case Study 3.1 Figure 1 *Floodwaters destroy a canyon road connecting the City of Boulder and mountain communities, September 2013.*

Source: City of Boulder

4 http://www.coemergency.com/



Case Study 3.1 Figure 2 *Urban flooding extent within the City of Boulder during the September 2013 flood.*

Source: City of Boulder

effective (Colorado Division of Homeland Security; City of Boulder). What made the area resilient to the devastation? Based on interviews, historical documents, and participant observation, this Case Study demonstrates that actions in three major categories increased resilience:

1. Physical systems
2. Human systems
3. Legal and cultural norms

PHYSICAL SYSTEMS

Plan for physical system failure: Virtually all physical systems will eventually fail; designing them to fail in nondamaging ways is critical to resilience. Open space or transportation greenways border many of the creeks in Boulder County, providing recreational opportunities and preserving ecosystem biodiversity. During floods, these trails and paths "failed" in their primary roles, taking on their planned secondary role for floodwater conveyance. This allowed space for creeks to overflow, entrain, and carry large debris and scour and deposit sediments with little impact to built infrastructure or people.

Additionally, the city has spent roughly US$45 million on flood risk reduction projects since 1999 (City of Boulder), knowing that eventually even the best-mitigated creek will overflow. The city has purchased and removed buildings in flood-prone areas and passed building codes to prohibit new development in "high-hazard" flood zones. Bridges have been raised to accommodate deluges of water and debris. Automatic floodgates have been constructed around buildings that sit creek-side. This planning paid off during the floods, with floodwaters routed through Boulder City with relatively minimal impact. Nonetheless, Boulder was also lucky to receive significantly smaller flood peaks than many neighboring communities.

Prevent failure of critical physical systems through redundancy: Redundant systems, such as a backup diesel generator at the Boulder Water Treatment Plant, can prevent the loss of critical systems. However, main and backup systems must have different sources of vulnerability. Although having multiple roads providing access into the mountains appears redundant, in Boulder County, six of the seven roads between the plains and the mountain communities failed because they were at the bottoms of canyons next to creeks and were washed away. Furthermore, as a result of the loss of roads, it proved almost impossible to transport the diesel required to keep the backup generator at the Boulder Water Treatment Plant in operation. This highlights the need to consider the potential for cascading failures in assessing resilience and to assure that backup and redundant systems do not have common points of failure.

Build in diversity: Many of the physical systems that failed during the flood would benefit from a more diverse, distributed, multiple-small-solutions approach. For example, many homes outside the floodplain suffered substantial damage from sewage upwelling in basement drains. Although refurbishing the entire sewage system is prohibitively expensive, there are opportunities to strengthen system performance through lining sewer pipes and installing backflow devices in individual households. Over the longer term, moving to a distributed sewage treatment system or encouraging the development and adoption of composting toilets could dramatically improve resilience.

HUMAN SYSTEMS

Support individual capacity: Flood preparedness, response, and recovery were strongest where individuals had access to basic resources and were able to act with creativity to address the problems at hand. For example, a network of civilian ham radio operators became the backbone of the communications network for many mountain communities. Many of the operators received training following a previous wildfire in 2010. Similarly, the sewage and potable water systems in the City of Boulder were maintained primarily through the ingenuity and resourcefulness of staff that felt free to take needed action without fear of reprisal. Utilities personnel were out in the middle of the night building a concrete cradle around the main sewage pipe to the treatment plant where it had become exposed along the river; their unorthodox solution kept the pipe intact. Because the road to the water treatment plant was lost, diesel for the water treatment plant backup generator was loaded onto pickup trucks and the drivers told to find a way to the plant. Local mountain residents provided information and suggestions, and the drivers were able to create a route through fields and on abandoned four-wheel drive roads.

Develop networks: Strong collaboration among county nonprofits, the faith community, and city governments dramatically aided the initial response to the floods. Active community groups, originally developed for other purposes, rapidly came together to aid victims.

Maintain broad access to resources: Access to outside resources, such as private-sector stores in the Denver Metro Area, the national disaster clean-up industry, outside volunteer groups, strong financial institutions, insurance, and other sources of outside financing all sped response and recovery. In places where access has been limited, recovery has been slowed or halted. The city and county were still seeing new aid cases arrive sixteen months post-flood, for example from undocumented migrant communities where fear of reprisal initially prevented households from seeking aid.

Develop avenues for learning: Much of the resilience seen in flood response and recovery resulted from modifications made to improve upon less-resilient preparation and response to previous disasters. The economic downturn in 2008 left many organizations in the nonprofit and faith communities scrambling for funds while they tried to respond to increased demand. The networking developed to address needs at that time strengthened the community as a whole and provided a strong foundation for rapid collaboration during recovery. A large wildfire in the County in 2010 provided useful lessons for emergency personnel, highlighting areas where better communications, early warning techniques, resident capacity for preparedness and response, and response and recovery coordination were needed. The progress made in all of these areas was readily apparent during the flood event.

The City of Boulder has made a point of learning, both from previous flooding events in the region, such as the Big Thompson Canyon flood of 1976 that killed 145 people in a neighboring county, as well as through activities like extensive flood-zone mapping. A culture of learning, at all levels of society, is critical to building and maintaining resilience. Where learning is inhibited, such as due to threat of litigation, it is critical to build in forums that foster cross-sectoral, multilevel learning from the disaster event, the response, and the recovery.

LEGAL AND CULTURAL NORMS

Adapt legal requirements to enable response and recovery: During and following the flood, Boulder County cities, towns, and the county as a whole modified many existing legal requirements around waste disposal, construction permits, and other flood-related issues to enable rapid response and reduce the financial burden on residents. However, laws about construction in floodplains continue to delay reconstruction in many places where creeks have moved. Where creeks moved, some residents are no longer in floodplains and other residents have become newly at risk. In both cases, the legal frameworks have not yet been updated to reflect new realities, and, until they are, government staff cannot approve building permits. This is further complicated by the challenges of understanding whether these types of events are likely to become more frequent under climate change, in which case flood plain maps need to be modified to reflect new realities.

Promote a culture of collaborative self-help: Many citizens overestimated the assistance that government could provide in disasters. The Boulder County mountain communities have learned this lesson well. In response to the 2010 fires, the mountain communities established the fully volunteer Inter-Mountain Alliance. This group provided core communications capacity and self-rescue services for at least five days during and immediately following the flood when most of the mountain communities were inaccessible to rescue workers. Boulder County as a whole is now looking at ways to transfer these lessons to the plains communities and build a stronger culture of neighborhood collaboration and self-help.

A collection of Boulder County volunteers have established BoCo Strong, a county-wide resilience network whose first actions have been to launch a local Voluntary Organizations Active in Disasters group. The City of Boulder is similarly focusing on strengthening social networks and is in the process of hiring a city neighborhood coordinator tasked with outreach to and capacity-building of city neighborhoods and communities.

CONCLUSION

Modern society is increasingly dependent on complex, rapidly evolving systems for survival:

- Our food and water comes from distant sources that are beyond our control;
- Food, water, shelter, and livelihoods are often highly dependent on power and transportation systems, which can lead to a cascading failure of systems;
- In-person interactions increasingly involve transportation over miles, and in times of crisis we often do not know the people next door.

Climate change is likely to intensify rainfall, fire, and drought in Boulder County. This makes the resilience of core systems, of people and organizations, and of legal and cultural norms ever more important.

The City and County of Boulder are in the process of building back from the floods and, in doing so, are thinking about how to build back better. However, they also recognize that infrastructure alone is insufficient. A core element of the building back is developing stronger communities within the city and county across all sectors – individuals, aid organizations, government, private sector, faith groups – and educating those communities about the actions they can take to be more resilient.

development of the built environment and greater amounts of impervious surfaces can have dramatic impacts on the rate and volume of rainwater runoff, resulting in accelerated flood frequency.

3.5.1 Financial Instruments and Public–Private Partnerships

Financial capacity-building is another essential disaster risk reduction strategy in urban areas prone to natural hazards and the impacts of climate change. Developed mostly through public–private partnerships, financial instruments such as insurance or tax incentives for retrofitting, relocation, and redevelopment practices are some of the ways that financial capacity for DRR can be developed (see Chapter 7, Economics, Finance, and the Private Sector).

As many researchers have pointed out, the poorest urban populations are usually hit hardest by disasters (see, for instance, Wisner et al., 2004; and see Chapter 6, Equity and

Box 3.4 Climate-Resilient Housing in Gorakhpur, India Selected as Lighthouse Activity 2013 by UNFCCC

Nivedita Mani and Shiraz A. Wajih

Gorakhpur Environmental Action Group

Community-Based Micro-Climate Resilience has helped the urban poor communities in Gorakhpur, India, to adapt to climate change by designing and building a new type of affordable flood-resilient house (see Chapter 11, Housing and Informal Settlements). Using locally available bricks and energy-saving techniques, this has proved to be environmental friendly, both in terms of optimization of resources and energy efficiency.

Mahewa ward of Gorakhpur is prone to flooding and waterlogging during the monsoon season. People living in this community are poor, marginalized, and particularly vulnerable to the impacts of climatic hazards, including floods, cyclones, changing rainfall patterns, and heat waves. Lack of affordability and technological knowledge resulting in inappropriate construction of houses adds further vulnerability to their lives during disasters.

The Gorakhpur Environmental Action Group (GEAG) along with the technical support from Sustainable Environment and Ecological Development Society (SEEDS) India designed a low-cost model house to meet local needs that can be easily replicated throughout the community. This house features unique design elements that limit climate change impacts such as higher plinth levels to reduce the risk of waterlogging, walls constructed to moderate temperature, and earthquake-proofing. The house is resilient to climate and produces fewer carbon emissions. GEAG can help interested households in accessing bank loans for construction of this type of house. This initiative was awarded a 2013 "Lighthouse Activity" by the United Nations Framework Convention on Climate Change (UNFCCC)'s 19th session of the UN Conference of the Parties.

Environmental Justice, for more discussion). With no private insurance to rely on and no personal savings, the poor are often unable to recover economically, requiring often financial assistance from the government, which also bears the burdens of emergency services, debris clearing, and infrastructure repair. The inability of the poor to participate in local transactions feeds back onto the larger macro economy; reducing government revenue and delaying recovery further, resulting in a vicious cycle of nonrecovery (Schnarwiler and Tuerb, 2011).

Studies by the G20 and the Bank of International Settlements (BIS) detail the importance of sovereign disaster risk-financing strategies, particularly in low-income countries where many live in poverty. A study by the G20, *Improving the Assessment of Disaster Risk to Strengthen Financial Resilience* (WB, 2012), finds that the macroeconomic impacts of disasters in countries that are not adequately prepared to cope with them range from stunted economic growth due to decreased tax revenues, loss of employment, and increased poverty to health effects, such as impaired cognitive ability of children in the wake of natural disasters due to temporary malnutrition. The study from BIS, *New Evidence on the Macroeconomic Cost of Natural Catastrophes* (von Peter et al., 2012), draws similar conclusions on the long-term health and economic impacts of natural disasters and adds that societies with a mature insurance market recover more quickly after an event – in some instances even showing positive economic growth.

Insurance instruments designed by the private reinsurance industry to address the needs of governments and other public-sector entities can play a significant role in holistic disaster-risk financing schemes. These public–private insurance partnerships transfer catastrophe risk from government entities to the private insurance market, provide governments with liquidity in the immediate wake of a natural disaster, and reduce the need for budget reallocation or tax increases to finance disaster recovery. These solutions also give government decision-makers an independent market-based estimate of climate and weather risk. By putting a price tag on unmitigated risk, a government can make more educated decisions in how to allocate its financial and human resources toward risk prevention and mitigation.

Numerous examples of successful public–private partnerships exist both in developing and developed economies. For instance, the government of Mexico uses a combination of traditional indemnity insurance and a catastrophe bond to protect itself from the impacts of tropical cyclones and floods.

The Caribbean Catastrophe Risk Insurance Facility (CCRIF SPC) provides the sixteen Caribbean community (CARICOM) countries with tropical cyclone protection. Since 2007, CCRIF has already paid out eight times, with a total of more than US$32 million, to a subset of its member countries. In 2014, the CCRIF announced plans for expansion into Central America to increase the financial resilience of these countries to tropical cyclones and floods.

In June 2014, the CCRIF launched excess rainfall insurance to protect its member countries against the financial impacts of heavy downpours and flooding. Heavy rains that occurred in St. Vincent and St. Lucia during Christmas 2013 caused more than US$100 million in damage and demonstrated the Caribbean's vulnerability to extreme rainfall produced by a trough of low pressure that moved through the region. Like its traditional natural catastrophe counterpart, the CCRIF XSR product has already demonstrated its benefit. Anguilla received a payout of US$493,000 after rains from Hurricane Gonzalo in October 2014 inundated the island nation. In November 2014, the government of Anguilla received its second payout, in the amount of US$560,000, while St. Kitts and Nevis received a payout of just over US$1 million.

Public–private partnerships have also been utilized by municipal entities. In 2013, after the New York Metropolitan Transit Authority (MTA) experienced a US$5 billion loss from Hurricane Sandy, the insurer for the MTA, First Mutual Transportation Assurance Company, sponsored a parametric, or index, catastrophe bond to protect the MTA against storm surge losses. The US$200 million MetroCat Re bond produces a 100% payout to the MTA if storm surge values exceed predefined triggers at various tidal gauges throughout the New York metropolitan area. This is the first storm surge-only catastrophe bond.

Natural hazards and climate change pose a real threat to urban economies and communities. The private sector can and should be an important partner to individuals, businesses, and governments at all levels by assuming some of the natural hazard risk and increasing the financial resiliency of governments, their populations, and economic producers in the aftermath of a natural catastrophe.

3.5.2 Ecosystem-Services Management

Ecosystems service management can mitigate disaster risks and build resilience in urban systems. Ecosystems sustain the livelihoods of communities and reduce their physical exposure to hazards (see Chapter 8, Urban Ecosystems)(CATALYST, 2013). Wetlands, forests, and coastal reefs serve as natural protective barriers against the impacts of storms, landslides, floods, and droughts. Ecosystems services include nutrient dispersal and cycling, seed dispersal, primary production, and provisioning services (MEA, 2005; de Groot et al., 2002). A wide variety of products and material and nonmaterial benefits can be experienced by urban residents and provide positive conditions for urban resilience. Key products and benefits include, for example, food, fuel, water, fodder, fiber, genetic resources, medicines, carbon sequestration and climate regulation, waste decomposition and detoxification, water and air purification, natural hazard mitigation, pest and disease control, erosion control, and cultural services (MEA, 2005; de Groot et at et al., 2002).

However, ecosystem services may and often do fall outside of the administrative boundaries of municipal governments. This implies the need for development approaches that consider a city within its larger landscape and administrative jurisdictions, even if some areas are governed by nonmunicipal entities. Rural–urban connections need to be strengthened for fully effective urban DRR and CCA to proceed.

Case Study 3.2 Adaptation to Flooding in the City of Santa Fe, Argentina: Lessons Learned

Claudia E. Natenzon

Universidad de Buenos Aires/FLACSO Argentina

Keywords	Floods, disasters, institutional adaptation, risk management, communication
Population (Metropolitan Region)	580,000 (Demographia, 2016)
Area (Metropolitan Region)	4,957 km^2 (Cardoso, 2011)
Income per capita	US$11,960 (World Bank, 2017)
Climate zone	Cfa – Temperate, without dry season, hot summer (Peel et al., 2007)

In 2011, the city of Santa Fe won the United Nations Sasakawa Award for Disaster Reduction for the progress made in effective risk communication to the public (Gobierno de la Ciudad de Santa Fe, 2011). It was the first city in Argentina to join the global campaign "Making Cities Resilient. My City Is Getting Ready."

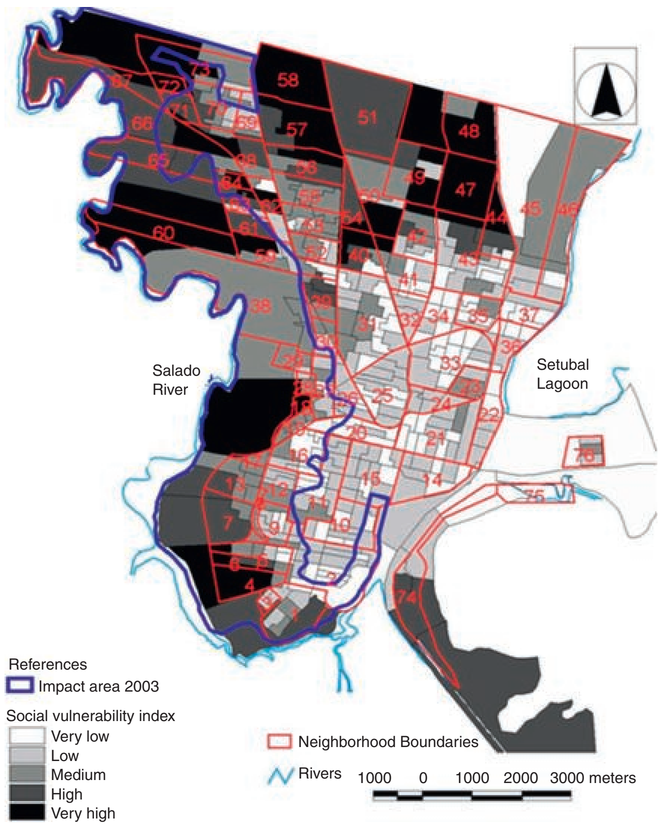
The municipal government of Santa Fe has achieved this award by overcoming hard experiences of catastrophic flooding, particularly those that occurred in 2003 and 2007.

The city is located between the Salado River to the west, Setubal lagoon to the east, and the Santa Fe River (an arm of the Paraná River) and islands to the south and is bordered to the north by the municipalities of Recreo and Monte Vera. The city has been exposed to catastrophic flooding originating in both of the rivers that surround it and extreme precipitation.

In late April 2003, the Salado River overflowed, causing loss of life, a large number of evacuees, and very significant material damage:

- A third of the urban area was under water.
- More than 130,000 people, 35% of a total of nearly 370,000 inhabitants in 2001 according to the National Population Census (Gobierno de la Ciudad de Santa Fe, 2015) and 27,928 households were affected.
- There were 23 deaths officially recognized, and 129 deaths from indirect causes reported by human rights organizations.
- The economic losses were estimated to be US$1,025 million, equivalent to 12% of Santa Fe's Provincial[5] 2002 gross domestic

5 In Argentina, the Provinces are the federal political units, with the same status of the States in USA and Brazil.



Case Study 3.2 Figure 1 *Social risk construction and the flood of 2003 in Santa Fe city. Geography Bachelor's Thesis, University of Buenos Aires.*

Source: Viand, 2009. "Before the Disaster"

product (GDP; CEPAL, 2003). These losses comprised direct damages of 35% and indirect of 65%. Private property and production sustained 91% of the losses; the public sector, 9%. By sector, losses were: 38% industry and commerce, 35% agriculture, 16% transportation, 8% housing, and 3% others. From the total impacted population, nearly 20% had no self-capability to respond, recover, or rebuild.

The floodwater entered the city from the northwest, in a 300-meter opening in an unfinished embankment defense. Water accumulation was reinforced by the inadequate aperture of the bridge (part of the Santa Fe–Rosario highway) located over the Salado River, which acted to retain the rising water and cause a backwater effect upstream. Within the city, the flood went south, covering the lowlands, and was retained because of the lack of finished levees and the inadequate or outright nonfunctional pumping stations.

The lack of reaction from authorities and protracted discussions with the contractor who built the highway over the embankment delayed the opening of channels to expel water, allowing it to reach the city at two times the level of the river. Once flooding receded, response organizations were lacking, and many problems in reconstruction generated a widespread social crisis and distrust in state institutions.

Four years later, in March 2007, the city was flooded again. This time, the water came from prolonged convective rains over the city in unusual quantities, an extraordinary but predictable phenomenon. Runoff from these waters was hampered by the annual floods of the Paraná and Salado rivers. As a result of the flood, a million agricultural hectares of land were flooded. Many communities were disadvantaged, including the city of Santa Fe, which had 30,000 evacuees, and much of the urban infrastructure was affected.

According to the Argentine Red Cross (ARC) the region sustained

> "electricity cuts (mostly preventative), damage to infrastructure making some areas inaccessible, suspension of school activity in some towns for weeks, and a significant loss of soybean and alfalfa crops. … At the early stages of the emergency, local discontent with the assistance being provided by local authorities grew, and local protests took place to demand improved assistance. Some warehouses and trucks containing humanitarian aid were looted by protesters. This created an atmosphere of insecurity and the police and naval authorities increased patrols and controls during the initial days of the emergency. At the beginning of the emergency, local supplies were less available and an increase in prices of basic food stuffs was registered" (DREF, 2008).

At the time of the second flooding, some defenses had been built, and the key plans to reduce the city's risk included (1) a system of clean drains, (2) reservoirs in good repair and of adequate depth to withstand heavy rains, and (3) a well-maintained pumping system to ensure operation. However, these planned actions were not realized. Technical reports prepared after the flood show that both reservoirs and sewage systems were not maintained and were insufficient and that 60% of the pumping stations (27 of a total of 45) were not operational at the beginning of the crisis. Nor had a warning system and a contingency plan been developed as promised after the flood of 2003.

This second great flood had a direct impact on the election for city mayor that year. The new city management for the 2007–2011 period put flood prevention on the political agenda as one of the central issues in the development plan of the city. Using the concept of disaster risk management (DRM), a communication program for the public was implemented, and this motivated the UN award. This Risk Communication Program has included workshops, conversations, and courses with more than sixty community organizations and forty-five neighborhood commissions; capacity-building for teachers; and training courses for journalists and social communicators. With the involvement of the Santa Fe Red Cross, some school plans for emergencies were made, and more than 5,000 people were invited to visit and inspect the city's drainage system. Finally, the Culture Department created "Agua Cuentos"("Water-tales"), performed for 3,000 students in twenty locations over the course of three years.

3.5.3 Building Community Institutions and Developing Capacities

Public participation in disaster risk management, including participatory planning and social capacity development, is essential to the effectiveness and implementation of disaster risk reduction actions. Increasing the capacity and awareness of both governmental and nongovernmental stakeholders such as citizens, school children, media, elected representatives, and government officials helps in policy and programmatic changes, enforcement, prioritization, and ownership of resilience activities at the local level. It also helps in addressing areas of concern related to basic services, ecosystems, infrastructure, and land-use planning.

The experience of communities and their knowledge about local issues can be helpful in identifying problems and negotiating solutions. However, strategies focusing on collective groups rather than individual members of the community have been found to be most effective. This approach helps to improve decision-making in all sectors of the community, with the goal of producing effective disaster management interventions. To sustain disaster risk reduction, bottom-up approaches and multi-stakeholder engagement in the resilience-building process is a prerequisite for cities and especially critical in urban areas because they face resource challenges in terms of human, technical expertise, and budgetary allocations. This engagement can be achieved by building community institutions from neighborhood to city levels, developing their capacities as well as those of government officials, and raising awareness through the entire metropolitan region about disaster risk reduction and climate change action.

The city of Gorakhpur (Uttar Pradesh, India) has led the way with an experiment in community-led participation for urban climate resilience planning done by the local nongovernmental organization (NGO), Gorakhpur Environmental Action Group (GEAG) (see Box 3.4 and Figure 3.14). In recent years, city planners and policy-makers have realized the limitations of a top-down approach to urban planning. Historical methods have failed to address specific community needs and overlooked the potential of mobilizing local resources and capacity to solve problems. Taking shortcomings of the past into account, city planners and policy-makers have placed increasing emphasis on a participatory approach to develop sustainable and long-lasting solutions. In Gorakhpur, an area prone to floods and serious waterlogging further worsened by top-down approaches to governance, the process of building urban climate change resilience was adopted with the participation of the community and other stakeholders. People's participation was at the core of every step. Tools and methodologies were developed to create an enabling environment for building participatory urban resilience.

Figure 3.14 showcases a bottom-up approach for building resilience to climate change that works at three levels: neighborhood, ward, and city levels. GEAG's experiences have shown that, in a city like Gorakhpur with poor basic infrastructure facilities and weak governance, addressing issues through community participation helps achieve better planning, stronger governance, and greater accountability of the government. In addition, the role of municipal governments in Gorakhpur has been crucial in the success of these initiatives for sustaining the activities and ensuring long-term sustainability

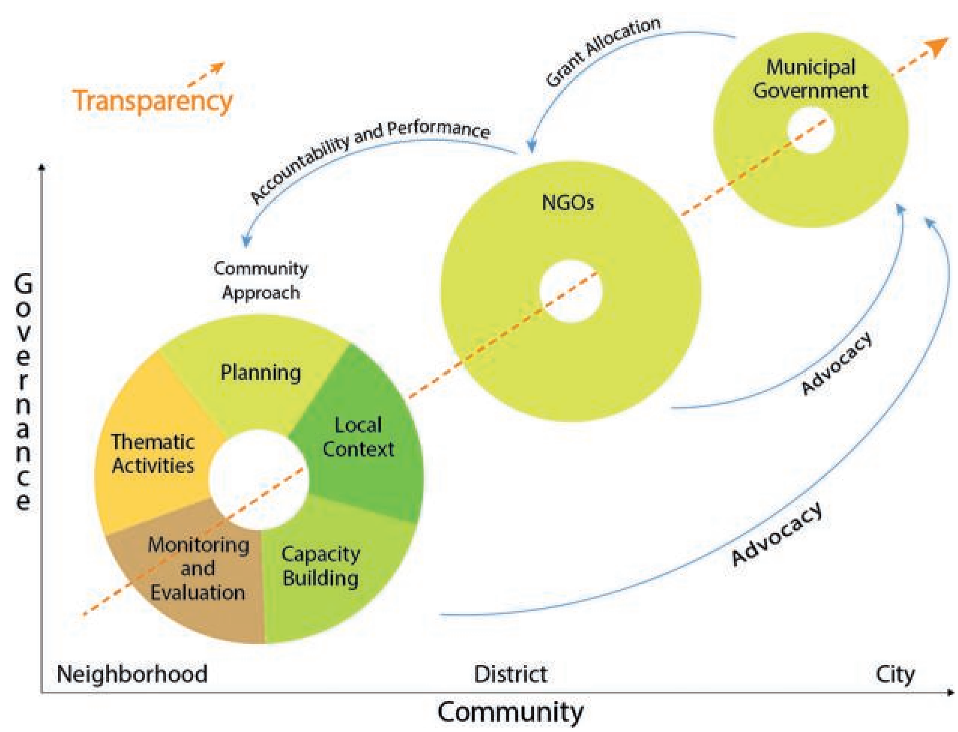


Figure 3.14 *Addressing systems, agents, and institutions through community participation.*

Source: Gorakhpur Environmental Action Group (GEAG), India of the processes. The capacity-building programs aimed at government officials have enhanced their knowledge about climate-related issues and is playing a crucial role in enhancing the sustainability of community-based interventions in Gorakhpur.

3.5.4 Post-Disaster Recovery and Rebuilding

Post-disaster recovery, rebuilding, and reconstruction is as a tool for disaster risk reduction and resilience building, particularly if it is planned ahead of disasters. Quarantelli (1999) poses the question, "Is it enough to bring back the past, or is something new or different necessary?" Several researchers have demonstrated how disasters can open rare windows of opportunity for instituting long-term change and altering the course of resilience. From a practitioner perspective, any recovery activity following a disaster that fails to reduce the population's exposure to risks is merely sowing the seeds for future disasters (IRP, 2007). Consequently, DRR is becoming increasingly recognized as an integral component of successful disaster recovery policy and rebuilding programming.

The recovery stage provides opportunities for risk reduction and the chance to break the cycle of destruction due to disaster. For example, researchers emphasize that future vulnerability can be reduced and community resilience can be improved through incorporating DRR measures such as developing minimum building codes and land-use regulations (Berke et al., 1993; Reddy, 2000). Yasui's (2007) study of recovery in two communities after the Kobe earthquake demonstrates that development practices and capacity-building efforts employed during a recovery process reduced overall community vulnerability in the long run. Other researchers insist that a good recovery program begins with a serious commitment to incorporate DRR and preparedness strategies to reduce future damage (Comerio, 1998).

Recovery planning and rebuilding should be an integral component of making cities resilient and thought out in advance. However, due to a lack of priority and resources dedicated to recovery planning in advance of a crisis situation, it is still rarely considered until disaster strikes.

3.6 Integrated Approaches to DRR and CCA

Various strategies are used to reduce disaster risks and build resilience as well as to mitigate GHGs emissions and adapt to climate change in urban areas. There is frequently a disconnection between CCA and DRR research communities and a lack of collaborative integrated work on these areas (Solecki et al., 2011). This is due to differences of emphasis

Case Study 3.3 Preparedness, Response, and Reconstruction of Tacloban for Super Typhoon Haiyan in the Philippines

Xiaoming Wang

Commonwealth Scientific and Industrial Research Organization (CSIRO), Melbourne

Dennis G. de la Torre

Climate Change Commission, Manila

Perlyn M. Pulhin

The OML Centre, Manila

Keywords	Typhoon, storm surge, disaster response, recovery and reconstruction, housing
Population (Metropolitan Region)	242,000 (Philippine Statistics Authority, 2016)
Area (Metropolitan Region)	201.72 km^2 (Philippine Statistics Authority, 2014)
Income per capita	US$9,400 (World Bank, 2017)
Climate zone	Af – Tropical, rainforest (Peel et al., 2007)

The latest disaster caused by Super Typhoon Haiyan[6] (locally named Yolanda) in the Philippines led to around 6,000 fatalities and more than 27,000 injured with thousands missing. The impact on communities was significant, considering that more than 12 million were affected, which represented more than 2.5 million families. The scale of the impact was also shown in the direct loss up to US$9 billion as a result of damage to infrastructure and agriculture in addition to more than 1 million damaged houses.

Tacloban is a small city located in a typhoon-prone area and is vulnerable to storm surges. It is among the areas that sustained significant damage and losses as a result of the Super Typhoon Haiyan. A total of 1,012,790 houses were damaged with a cost estimated at PhP303,837.0 million among the total loss of about US$13 billion (The Philippine Government, 2013). There were 4.4 million people among 930,000 families displaced in affected areas, which were mostly occupied by informal settlements where the occupants' livelihoods were considerably disrupted. The service loss of critical infrastructure including power and water supplies further hindered the recovery of local livelihoods and businesses. Meanwhile, social services, including health services and schools, suffered significant disruption due to damages, as shown in Case Study 3.3 Figure 1, further hampering the recovery. Based on the impact of Super Typhoon Haiyan on Tacloban City, this Case Study reviews the preparedness, response, and reconstruction activities

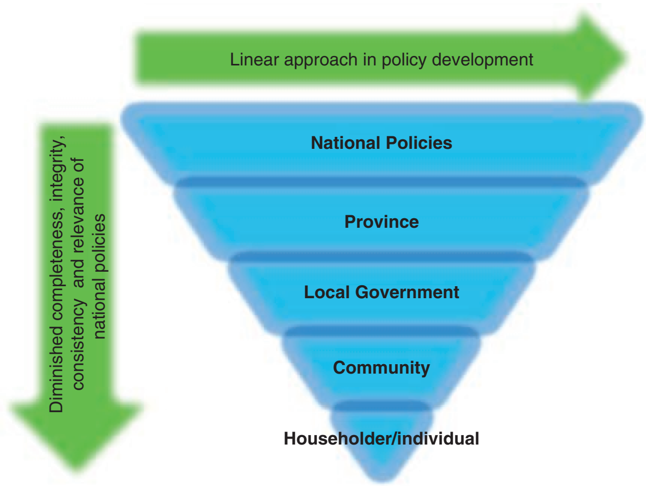
6 'A super typhoon has wind speeds of at least 100 knots/120 miles per hour.

Case Study 3.3 Figure 1 *Damages in Tacloban caused by Super Typhoon Haiyan.*

in the area as well as relevant policies and planning for managing natural disaster risks.

Prior to the disaster, the Philippine government developed the Climate Change Act of 2009, creating the Climate Change Commission (CCC), the National Strategic Framework on Climate Change (NSFCC), and the National Climate Change Action Plan (NCCAP) to guide the mainstreaming of climate change adaptation (CCA) in policy and planning. It enacted the Philippine Disaster Risk Reduction and Management Act of 2010, creating the National Disaster Risk Reduction and Management Council (NDRRMC), correspondingly the NDRRM Framework and the NDRRM Plan, to guide disaster risk reduction (DRR) actions in the Philippines. It also established the People's Survival Fund as a long-term finance stream for climate change actions.

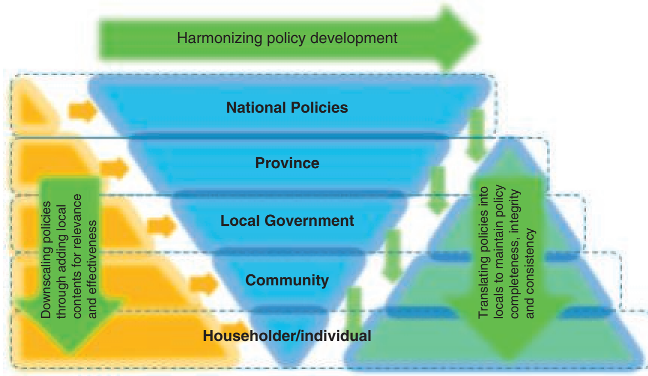
In reacting to the disaster, President Aquino appointed Senator Lacson as Presidential Assistant for Rehabilitation and Recovery, and the Department of Budget and Management issued a National Budget Memorandum including the creation of the Reconstruction Assistance for Yolanda (RAY) in the 2015 National Budget, calling for systematic integration of CCA/DRR. A total of 41 billion pesos was initially allotted for Yolanda rehabilitation, administered by NDRRMC and the Department of Social Welfare and Development. The Department of Environment and Natural Resources defined some areas in the city as "no-build zones" located 40 meters from shoreline, following the Philippine Water Code (the majority of residents, however, ignored these rules when rebuilding their homes). Finally, the Department of Labor and Employment established emergency employment programs with support from the International Labor Organization.



Case Study 3.3 Figure 2 *Gaps in development policy and actions for disaster risk reduction and climate adaptation.*

In hindsight, Super Typhoon Haiyan highlights critical gaps in managing disaster responses and recovery across tiers of government from national to city and local levels down to communities, households, and individuals, as shown in the Case Study 3.3 Figure 2, at both horizontal and vertical scales. The Philippines government has made significant efforts and great progress in developing national policies to mitigate the risks of natural disasters and climate change, but their relevance to implementation as well as their influence on practice diminished at the finer scale of provinces, municipal governments, communities, and householders, creating a significant barrier for the government to build a proper level of capacity for local communities and householders in response to natural disasters and climate change risks.

With a potential increase of extreme climate risks in the future as a result of climate change, policy development to enhance preparedness and prevention, especially of catastrophic events such as the Super Typhoon Haiyan, should be integrated into disaster management. It should also be reflected across all levels, as shown in Case Study 3.3 Figure 3, to harmonize DRR management and CCA policies into the legislative framework for sustainable development. The goal is to transform national policies into content aligned with the realities of provinces, city governments, communities, and households (and individuals, if necessary) while maintaining its consistency, completeness, and integrity with national policies in terms of visions and goals. Moreover, such finer-grained policies must supplement national policies at different levels, thus facilitating national capacity-building and DRR/CCA implementation across all levels. Finally, existing DRR/CCA policies in the Philippines can be further improved based on the policy nexus concept.



Case Study 3.3 Figure 3 *Implementing the policy nexus for climate adaptation and natural disaster risk reduction.*

between disaster risk and climate change research, with the former focused on the past and present and latter on the impacts of future risk (Thomalla et al., 2006; UNDP, 2004; Gencer, 2008).

Scholars and communities of practice have increasingly called for the need to apply a systems-based risk management and risk decision-making approach that takes into consideration both contexts (IPCC, 2012). Disaster risk reduction and CCA strategies are emerging worldwide as an important requisite for sustainable development. Disaster risk reduction and CCA policies and measures need to be implemented to build disaster-resilient societies and communities, with the aim of reducing risks while ensuring that development efforts do not exacerbate climate vulnerability.

Disaster risk reduction and CCA also share a common conceptual understanding of the components of vulnerability and the processes of building resilience that needs to consider the sensitivity and capacity as components of vulnerability, exposure, and magnitude and/or likelihood of the hazard. Both vulnerability and exposure are compounded by other societal and environmental trends, such as unplanned urbanization, ineffective governance structures, inequality, and environmental degradation. To reduce disaster and climate change risk, exposure needs to be minimized, sensitivity reduced, and capacity strengthened in ways that address both disaster and climate change risk simultaneously, in a dynamic process requiring continual effort across economic, social, cultural, environmental, institutional, and political domains. Thus, a multirisk analysis framework that accounts for the possible interactions among the threats, including cascading events, is needed, taking into account temporal (e.g., duration of the event and typical return period of extreme events) and spatial scales.

Performing quantitative multi-risk analysis presents many challenges. Disaster scenarios are often qualitative, related to one reference event, and rarely account for the related uncertainties. Furthermore, the risks associated with different types of natural hazards (e.g., volcanic eruptions, landslides, earthquakes, and floods) are often estimated using different procedures so that the produced results are not comparable. The events themselves could be highly correlated, or one type of threat could be the result of another one (e.g., floods and debris flows could be triggered by an extreme storm event, so-called cascading effects). Key characteristics of the elements at risk, represented by vulnerability to specific threats, are not constant and change over time. In particular, exposure to one type of hazard might increase the vulnerability significantly to other types of hazards. The challenge is to find innovative, efficient ways to collect, organize, assess, and communicate to urban planners, designers, and decision-makers the risk and vulnerability data on hazards and impacts as well as on mitigation/adaptation and the criteria of alternative policy and development scenarios while also accounting for inherent spatial-temporal dynamics. This becomes particularly important in the context of climate change-induced increases in risk at different spatial and temporal scales.

The Urban Climate Change Resilience Framework (UCCRF) developed by Institute for Social and Environmental Transition (ISET) is a conceptual planning approach to building resilience to climate change (see Box 3.5). It is designed for practical application and has been developed from and tested in field situations. The Framework addresses the need for an approach that clarifies the sources of vulnerability and addresses the complexities of climate adaptation, yet is simple enough for local practitioners to apply in their own context.

Community-based, national, and regional projects have impediments to integrating DRR and CCA because of donor requirements, the sometimes conflicting goals of partner organizations, and underlying policy frameworks. Opportunities do

Box 3.5 Urban Climate Change Resilience Framework

The Urban Climate Change Resilience Framework (UCCRF) is structured to build a broad understanding of urban resilience by describing the characteristics of urban *systems*, the *agents* (people and organizations) that depend on and manage those systems, *institutions* (laws, policies, and cultural norms) that link systems and agents, and patterns of exposure to climate change (Tyler and Moench, 2012). The characteristics that make a system resilient include:

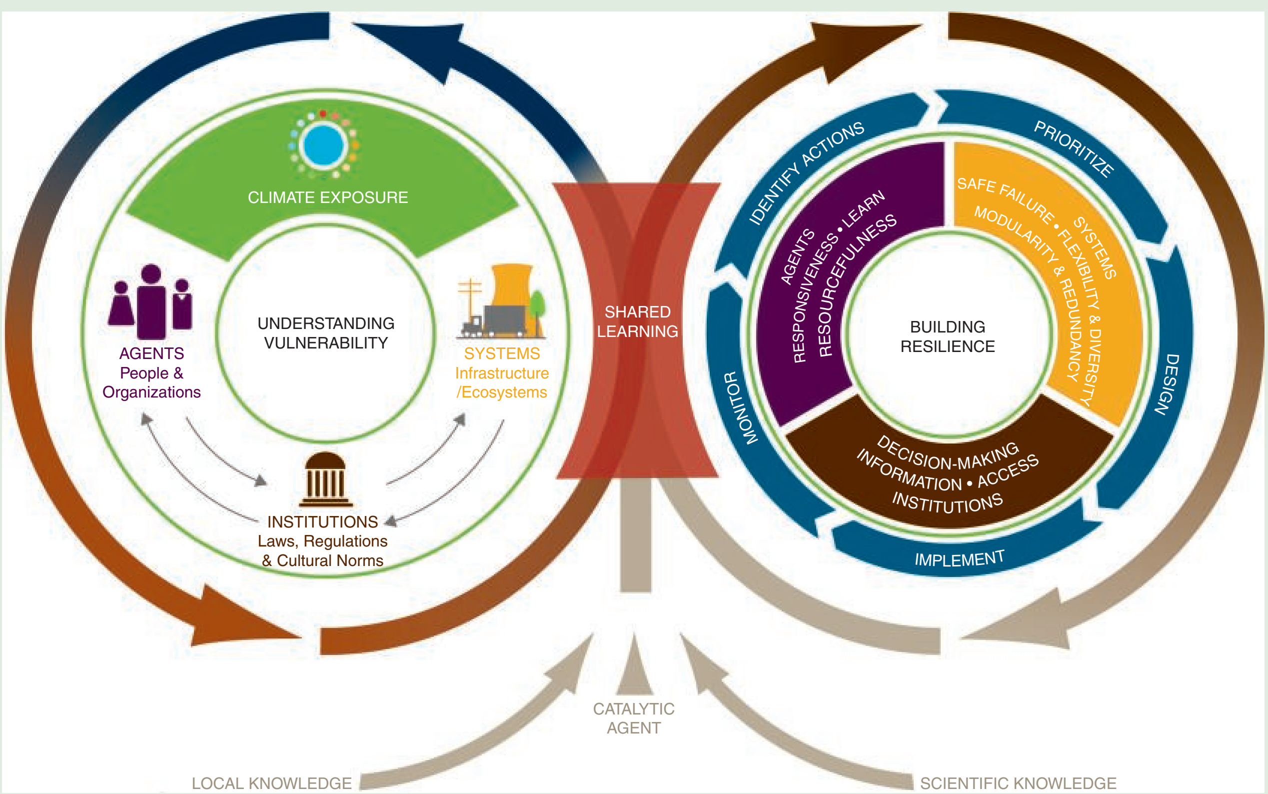
1. *Flexibility and diversity*. The ability to perform essential tasks under a wide range of conditions (e.g., multiple and geographically distributed water resources, both surface and underground)
2. *Redundancy and modularity*: A system that has spare capacity for contingency situations in order to accommodate extreme or surge pressures or demand (e.g., multiple routes in transportation, redundant cell phone transmission towers)
3. *Safe failure*: The ability to absorb sudden shocks, including those that exceed design thresholds (e.g., dikes that can be opened to fill flood retention zones outside city).

The agent is an essential subcomponent that includes individuals, households, and public and private-sector organizations. The *responsiveness* (capacity to organize and reorganize in an opportune time), *resourcefulness* (capacity to identify and anticipate problems; establish priorities, and mobilize resources for action), and *capacity to learn* (from past experiences, avoid repeated failure, etc.) are important aspects of agents to be considered in resilience building.

The concept of institutions in social sciences refers to the rules or conventions that constrain human behavior and exchange in social and economic transactions (aspects like decision-making, rights and entitlements, learning and change, and information flows are examples of the characteristics of a resilient institution).

The framework operationalizes these concepts through structured and iterative shared learning approaches that allow local planners to define these factors in their own context in order to develop practical strategies for local action to build urban climate change resilience.

The UCCRF focuses on vulnerable populations in urban locations and their marginalized subsistence that often lacks secure access to services and depends on fragile urban systems. This makes them especially exposed to system failures in the wake of climate-related stress. In addition to this, the framework provides information on agents and institutions as enablers of resilient systems in a city, thus defining three pillars of resilience-building within a city system: (1) strengthening fragile systems, (2) strengthening social agents, and (3) strengthening institutions.



Box 3.5 Figure 1 *The Urban Climate Change Resilience Framework.*

Source: Tyler and Moench, 2012

exist, however, and leadership is needed to bring together these two often overlapping fields. Developing an awareness of both DRR- and CCA-related initiatives, organizations, and policy arrangements will reduce duplication of efforts and thus contribute to effectiveness. Not only will existing organizations be able to share relevant experiences and lessons learned (perhaps from CCA and DRR practitioners, or vice versa), they will also be aware of gaps and future needs. Opening the dialogue between these groups serves to initiate, develop, and maintain the good relationships that are crucial to creating a supportive institutional architecture. Furthermore, by addressing vulnerability at the local level in a holistic sense, the community will benefit by receiving a well-targeted program, and DRR and CCA will inherently be incorporated alongside risks such as health, nutrition, disease, and other issues. By sharing lessons learned and successful practices, as well as sharing practices that perhaps were not effective, organizations can better utilize the funds that are available to achieve advances in their resilience to disasters today and tomorrow.

3.7 Barriers, Challenges, and Opportunities

Cities in low-, middle-, and high-income countries are focused on a range of issues associated with improving disaster risk reduction and climate change adaptation. Economic losses from environmental hazards have increased exponentially within the past decades. There is an increasing awareness that sustainable development, along with international strategies and instruments aiming at poverty reduction and environmental protection, cannot be achieved without taking into account the risk of natural hazards and their impacts in a world of changing climate. In this section, we examine some of the barriers and challenges to DRR in the context of climate change (see Chapter 16, Governance and Policy). Some critical considerations are listed in Table 3.2.

Table 3.2 *Top five recommended actions for decision-makers.*

Capacity	Have a dedicated person on disaster risk reduction (DRR) and climate change adaptation (CCA) in each agency with a clear mandate and hold the agency accountable for demonstrating DRR and climate change integration into its development and planning agenda.
Resources	Work with financing and development agencies; develop public–private partnerships to develop resources for DRR and climate change actions; forge partnerships between neighboring city governments and international organizations to share technical and knowledge-based resources. Promote advocacy and policy dialogue at the national level as well as with key donors of development initiatives.
Information	Have protocols for gathering and sharing of information (with other agencies, with the public, etc.) and devote more resources to the development of science aimed at DRR/climate change. Work and develop partnerships with the scientific community, NGOs, and the private sector for the development of knowledge and innovative products.
Planning	Work on solving current gaps in land-use planning, environmental management, licensing for construction, etc.; incorporate the long-term.
Public Participation	Initiate bottom-up approaches and advocate the participation of urban communities and civil society organizations because public participation is key to effective implementation for DRR and climate change.

3.7.1 Coordination

An enabling governance framework is essential for disaster risk reduction and climate change adaptation. However, lack of coordination among different levels of government and across sectors, and even within the DRR and CCA sector itself, can hamper these efforts (see Chapter 16, Governance and Policy). Some of the barriers and challenges are:

At the national level: One of the main challenges of DRR and DRM has been to transition from a response-oriented framework to a proactive vulnerability and exposure-reduction framework. Disaster risk reduction includes identifying and understanding risk; reducing risk; preparing for and responding to emergencies when they arise; and recovering, reconstructing, and rebuilding in fair and sustainable ways. To achieve these objectives, DRR ideally needs to be embedded within each sector (e.g., transport, energy). It is not a task only for a disaster response agency. Both DRR and climate change action have great potential to help cities plan for the longer term, something that is essential, but generally tough to implement in practice because political terms and financial decisions generally have shorter-term horizons.

At the national level, responsibility for DRR and climate change action should be part of a ministry or agency that has sufficient authority to enable mainstreaming at the sectoral, territorial, and municipal levels and that has access to financial resources (UNISDR, 2011). In Latin America, Colombia made an effort in this direction with the creation in 1988 of the National System for Disaster Prevention and Response (*Sistema Nacional Para la Prevención y Atención de Desastres*, SNPAD) (CEPAL and BID, 2007). This body enables, at least at a legislative level, an integrated DRM approach that is also integrating issues of CCA. There is also an inter-sectoral commission on climate change.

Recommendation: Pass national legislation that creates an integrated system of disaster risk reduction (DRR) and climate change adaptation (CCA) in one high-level agency with authority and resources. This is one way to integrate the topics and to give them decision-making relevance, thus providing a framework in which sectors and municipal governments can coordinate (PREDECAN, 2009).

At the regional level: Integrating DRR and CCA at city-relevant levels such as states and provinces is important mainly for two reasons: (1) it provides a link between the national and local, and (2) it allows for coordination between city governments. It is generally at the regional level that watershed and natural-resource management take place. However, regional bodies often do not exist or have a weak mandate and few financial resources.

Water, food, and other natural resources that cities depend on know no political boundaries. It is common, therefore, to find bodies at the regional level that manage resources such as water (e.g., the Mekong River Commission or the Autonomous Regional Corporations in Colombia, which are regional environmental agencies). Deficient regional planning can have a direct effect on city water resources and on urban flooding. It is important to have the right governance at the regional level to foster ecosystem services approaches and the valuation of natural resources.

At the municipal level: Because of the spatial nature of hazards and risk, the most immediate response and risk reduction measures happen at the municipal and city district levels. Small cities in developing countries may face resource challenges. Organizations such as ICLEI–Local Governments for Sustainability provide good platforms for city governments to exchange experiences. There are low-cost measures that can help reduce risk at the city level and that focus on being no-regret measures that have multiple co-benefits (e.g., employment creation, reduction of stagnant water, and focus on associated health hazards).

At the urban level, there can also be important gaps between policies and city government needs. In small countries like El Salvador, several services are the responsibilities of agencies at the national level (e.g., the Ministry of Public Works covers everything related to roads and water infrastructure). The intervention plan of such national agencies might not match city needs or interests. At the same time, another challenge is that there might not be enough human and financial resources at the local level, and there often exists needs for technical training and support.

Recommendation: Create more spaces for dialogue and joint planning between different levels and sectors of government. This requires increasing the capacity of municipal and state governments so they have the necessary technical personnel. Another useful strategy to build the capacity and collaboration of city-relevant governments is to incentivize them to share resources and personnel when relevant and necessary.

3.7.2 Capacity

Risk assessments need communications strategies and decision criteria in order to be translated into useful risk management interventions. Lack of scientific information and data or issues with data sharing are often challenges for risk assessments (see Chapter 16, Governance and Policy), and there is often a lack of capacity to conduct or update assessments.

Recommendation: More emphasis should be given to protocols for data collection and sharing, as well as for the sharing of technical equipment (e.g., meteorological stations) where needed. In addition, city governments need more professionals trained in risk and climate change at the urban level to conduct assessments and interpret them. They can weigh in when difficult choices have to be made.

The Open Data Institute (ODI) is a nonprofit organization that helps unlock supply, generates demand, and creates and disseminates knowledge to address local and global issues.[7] Using information gathered through the ODI, Resurgence,[8] an NGO promotes the use of open data, social media, and communication to foster risk reduction and resilience-building in city governments.

Recommendation: Municipal governments can also benefit from increased capacity in the use of negotiation tools such as role-playing games (Mendler de Suarez et al., 2012). For capacity development in urban professionals who need to integrate DRR and CCA into urban planning, development, design, and construction fields, professional associations can develop continuing education programs. Educational programs that focus on DRR and CCA is needed for all ages.

3.7.3 Resources

One of the biggest challenges in disaster risk reduction and climate change adaptation is to show that it pays to invest *ex-ante* in risk reduction and adaptation, especially when there are limited resources and competing needs. One way to show the

7 For more information, see ODI's website, http://theodi.org
8 For more information, see Resurgence website, http://www.resurgence.io/

savings from early action is to monitor interventions and account for avoided losses. Another way is to improve the tools used to prioritize investments, such as cost-benefit analysis.

It can be challenging to find resources for DRR and CCA. Investments that can reduce risk and increase adaptive capacity (e.g., setbacks in vulnerable coastal areas) are often not prioritized because benefits may only show at a later stage and are thus heavily discounted. There is a need for improved methodologies to incorporate DRR and CCA criteria into public investment decision tools such as cost-benefit analysis (Vorhies, 2012). Measuring costs and benefits can be challenging, especially when dealing with environmental and social issues, and cost-benefit analysis is heavily dependent on choice of discount rate (which is used to calculate future benefits and costs in present value). There is also a need to differentiate between direct economic benefits and extended economic benefits.

With support from Germany's *Gesellschaft für Internationale Zusammenarbeit (GIZ)*, Peru has been working to incorporate DRR and CCA criteria into the formulation and approval processes for public investments (Public Investment and Climate Change Adaptation [IPACC]). The methodology analyzes the project costs with and without risk reduction measures and thus includes a measure of "avoided costs"[9] (GIZ, 2012). There are also new tools that aim to account for the benefits provided by ecosystem services (e.g., InVEST)[10]. Another way to create awareness in Ministries of Finance on the importance of investing in DRM and CCA, one widely used by multilateral development agencies such as the Inter-American Development Bank, is to use probabilistic risk assessments to show potential losses. This also provides a good baseline to support the provision of financial resources and the prioritizing of interventions. Highlighting the benefits of ecosystem services for risk reduction is also proving beneficial for green infrastructure schemes in coastal communities.[11]

Assessments made in countries such as the Philippines and Malaysia on current efforts to address disaster risks and climate change, focusing particularly on aspects that can help build linkages between DRM and CCA, revealed the following impediments (Senga, 2012):

- Inadequate provision of high-resolution meteorological data for detecting trends and validating models;
- Poor access to physical (e.g., hydrological) and socioeconomic datasets for assessing risk;
- Insufficient incorporation of implications of climate change in risk assessments;
- Analyses of potential climate change impacts stop short of identifying practical adaptation options;
- Gaps in awareness and understanding of risk and climate change projections;
- Relatively weak coordination mechanisms regarding CCA;
- Underdevelopment of a preventive DRR approach;
- Diversion of funds due to disaster emergency response.

3.7.4 Other Challenges

Limits of top-down approaches: Historical top-down approaches have sometimes failed to address specific local needs; therefore, bottom-up approaches – initiatives developed by urban communities and their participation in programs developed by municipal governments and other stakeholders – are a prerequisite for cities in building resilience. Inadequate government capacity and resources and the lack of reliable scientific data mean that the role of urban communities in disaster preparedness has become more crucial. The recent devastations by floods in Asian countries including Indonesia, Malaysia, Thailand, and India have raised serious questions in cities in regard to the extent to which development plans are meeting local needs, including addressing disaster risks. In this context, it is crucial to highlight a community's ability to reduce its own disaster risk as well as the areas where additional support are needed. Local initiatives at the grassroots level should be linked with appropriate top-down strategies and city government interventions and policies (Anderson and Woodrow, 1998; DFID, 2005; Fraser et al., 2006). This ensures the sustainability of the approaches adopted and enables access to outside knowledge that may assist in vulnerability reduction.

There is often a shortage of local municipality experience in incorporating climate change into DRM despite the desire to do so. Interviews showed that municipal governments in Costa Rica in general are concerned about the potentially hazardous impacts of climate change (Box 3.6) (Hori and Shaw, 2011). Even small municipalities in rural areas demonstrated their conceptual understanding of the importance of incorporating climate change impacts into DRM and local development planning, especially in the agriculture and tourism sectors important to their sustainable local economy. The municipalities receive information related to climate change from a variety of media and sources that include both international policy bodies (such as Conference of Parties or ICCP meeting information received via Internet or TV). However, these municipalities are uncertain about how to incorporate potential climate change impacts into local DRM planning in practice. This situation coincides with the many challenges that disaster risk re-education and CCA face, and thus local municipal governments often have no long-term solutions to their communities' problems nor have they developed their coping mechanisms and capacities.

Prabhakar et al. (2009) suggest that climate change mainstreaming into local development planning could be initiated with capacity-building by local DRM personnel and policy-makers. This concept corresponds to that of Perez (2008), who explains the importance of local key stakeholders' critical understanding of CCA. Vignola and colleagues (2009) assert that national policy-makers should empower local actors to facilitate adaptation processes. Thus, capacity-building and empowerment of local actors are considered key factors for establishing and improving DRM planning at the local level.

9 For more information see IPACC's webpage, http://www.ipacc.pe/.
10 See Natural Capital Project – Invest: http://www.naturalcapitalproject.org/InVEST.html
11 Building with nature for coastal resilience. Wetlands International, Deltares, The Nature Conservancy, Wageningen University. http://www.wetlands.org/NewsandEvents/NewsPressreleases/tabid/60/Default.aspx

Box 3.6 Incorporation of Potential Climate Change Impacts into Disaster Risk Management in Costa Rica

Tsuneki Hori

Inter-American Development Bank, Washington, D.C.

Rajib Shaw

Integrated Research on Disaster Risk Program, Kyoto University

Some municipalities in Costa Rica, especially those in the greater metropolitan area, are engaged in concrete planning actions related to the incorporation of climate change into disaster risk management (DRM). Travel agencies and the emergency committee in the Municipality of Tibas have recently formed a coordination mechanism to prepare for an increasing number of floods and protect tourists from future climate-related hazard events. The Santa Ana municipality is in the process of regulatory plan updates that will allow validation of land-use licenses for local tourism operations, including restaurants and hotels. The process of licensing incorporates reducing potential disaster risk related to recent flood damages. Many municipalities in Costa Rica do not sufficiently recognize the national policy planning instruments such as the National Tourism Development Plan 2010–2016 and the National Strategy on Climate Change (ENCC). Nonetheless, municipal governments do take small but necessary planning actions related to disaster risk reduction (DRR) in the context of climate change, independent from national policy priorities. In addition, the tourism sector is important for the local economies in Costa Rica, and municipalities in general are concerned about additional disaster impacts associated with climate change. This arena of local initiative constitutes an opportunity for improving DRR planning at the local level, independent of the national policy priorities.

Many Costa Rican municipalities engage in developing information related to longer-term disaster risk scenarios. For example, the municipality of Santa Ana is analyzing its future water demand, taking into account future real estate development for commercial infrastructure and residences. The risk analysis for this sector incorporates future flood estimation as one of its variables. The municipality does not have an in-depth capacity for this analysis, so national universities provide technical and analytical support. For sustainable groundwater use, the Municipality of Belen has developed a regulation that requires relevant information on potential impacts of climate-related hazards. The study was conducted in collaboration with the National Meteorological Institute (IMN).

These activities represent efficient local approaches to developing relevant information on climate-related impacts. First, municipalities conduct research often for their local needs, independent of national priorities or policies. Second, the municipalities do not always use advanced technology to develop information on climate-related risk scenarios generally used by the international science community; instead, they conduct research with the tools that they have. Third, when municipalities need additional technical support, they request support from technical institutions or universities. The essence of this approach may be applicable for many sectors and may be an opportunity to incorporate climate change into local DRR planning.

Source: Hori, T. and Shaw, R., 2011

Other development priorities: For the majority of cities, addressing the potential impacts of climate change is not their top priority (Bai, 2007). For example, in a study by Hori and Shaw (2011), certain municipalities of Costa Rica asserted that there are a variety of urgent local operational demands, including housing construction (the Municipality of Aguirre), permission for commercial construction (the Municipality of Desamparados), reduction of unemployment (the Municipality of Esparza), and reconstruction of infrastructure damage caused by recent disasters (the Municipality of Garabito). Moreover, most of the municipalities in this study have no or inadequate human resources that can be responsible for CCA. This situation is a serious constraint in the mainstreaming of hazards and the impacts of climate change into local development planning.

To mainstream the consideration of climate change impacts into each sector, coordinate policies with other priority issues, and incorporate these policies into local development planning processes, assigning a single point of coordination for CCA and DRR at the city government level may be a first step to binding local priorities and DRR or climate change initiatives. This would also address the lack of interdepartmental DRR co-ordination at the local level.

Urban development planning: It takes a long time for municipalities to develop local development plans, and this creates problems in implementation. One example is the Municipality of San Ramon in Costa Rica, which took more than eight years to develop its regulatory plan (Hori and Shaw, 2011). It is true that many of the municipalities in Costa Rica and in other developing countries lack technical knowledge, as well as the human and financial resources needed to produce local development plans. It is important to understand this reality and consider strategies for better scoping of local DRM planning on a longer time scale.

3.7.5 Recommendations for the Integration of DRR and CCA in Urban Areas

Dividing areas of action into sectors has often proved organizationally convenient in government and academia but can undermine a thorough understanding of the complexity of and interactions among the human and physical factors involved in the definition of a problem at urban scales. A more integrated approach would facilitate recognition of the complex relationships among diverse social, temporal, and spatial contexts in cities. Decision processes that employ participatory methods and decentralization within a supporting hierarchy of higher levels could enhance many urban DRM organizations currently faced with climate-related decisions. The following areas, some of which have been pursued by governments, civil society actors, and communities, are recommended or proposed to foster such integration among adaptation to climate change, DRR, and management in cities.

If progress is to be made in reducing the impacts of disaster and climate change on developing countries and particularly on the poor, an adequate information base for decision-making is needed, one that includes disaster risk exposure as well as the socioeconomic and environmental dimensions of vulnerability. Information needs to be provided in a format that meets the practical demands of the targeted stakeholders, with emphasis placed on a process of monitoring and updating if it is to reflect the dynamics of a changing climate and shifting parameters of municipal vulnerability. However, information is only useful if it is embedded in an enabling governance framework that allows for action aimed at reducing vulnerabilities at the local to national levels. The ability to coordinate expertise to galvanize action at all scales is crucial, including the ability to leverage financing for science. Furthermore, risk management cannot be viewed in isolation from other pressures of development but should instead be part of an integrative effort toward reducing vulnerability and promoting livelihoods.

Annex 3.1 Stakeholder Engagement

Ebru Gencer is the Founding Director of the Center for Urban Disaster Risk Reduction and Resilience (CUDRR+R) and the Co-Chair of the Urban Planning Advisory Group (UPAG) to the Special Representative of the Secretary-General of the United Nations for DRR. She has taken part in multiple DRR and resilience-building activities since the inception of the UCCRN ARC3.2 process including, among others, being part of the Expert Team that drafted the New Ten Essentials for Making Cities Resilient that can be used by city governments and other stakeholders; working with municipal governments for UNISDR/WMO's Building Resilience to Disasters in Western Balkans and Turkey project; and currently working on a CDKN/IDRC/FFLA-funded project; on Climate Resilient Development in Latin American cities.

Megan Linkin is specialized in public–private partnerships (PPPs) and works within the re-/insurance industry. She has had numerous meetings with public-sector entities covering the topics in this chapter.

Claudia Natenzon has been an expert of the Working Committee in Risk Management of the National Ministry of Science, Technology and Innovation in Argentina, advising this group in the formulation of a protocol to prevent, respond to, and rebuild urban areas after flash floods, as well as being an expert for the Third National Report to the Climate Change Convention of Argentina, diagnosing Argentina's vulnerability impacts, the identification of dangers coming from the climate change process (in collaboration with climatologists), and the evaluation of risk in this climate change context.

Mattia F. Leone has been involved, as part of the PLINIVS Study Centre of University of Naples Federico II, with drafting agreements with the Campania Region and the National Department of Civil Protection, and for the drafting of preparatory guidelines for the implementation of the first regional regulations and local building codes for volcanic risk-prone areas. The specific topic of an integrated approach to geophysical and climate change-induced hazards has been developed in the context of an agreement between the Department of Architecture of University of Naples Federico II and the City of Poggiomarino as part of preliminary studies related to the development of the new Urban and Building Code.

Chapter 3 Disasters and Risk

References

AIR Worldwide. (2013). AIR estimates insured losses from super typhoon Haiyan between USD 300 million and USD 700 million. AIR Press Release. Accessed January 13, 2016: http://www.air-worldwide.com/Press-Releases/AIR-Estimates-Insured-Losses-from-Super-Typhoon-Haiyan-at-Between–USD-300-Million-and-USD-700-Million/

Anderson, M. B., and Woodrow, P. J. (1998). *Rising from the Ashes: Development Strategies in Times of Disaster*. Intermediate Technology Publications.

Bahadur, A., and Tanner, T. (2014). Transformational resilience thinking: Putting people, power and politics at the heart of urban climate resilience. *Environment & Urbanization* **26**(1), 200–214.

Bai, X. (2007). Integrating global environmental concerns into urban management. *Journal of Industrial Ecology* **11**(2), 15–29.

Balk, D., Montgomery, M. R., McGranahan, G., Kim, D., Mara, V., Todd, M., … and Dorélien, A. (2009). Mapping urban settlements and the risks of climate change in Africa, Asia and South America. *Population Dynamics and Climate Change, 80*.

Barton, J., and Heinrichs, D. (2011). Santiago de Chile: Adaptation, water management, and the challenges for spatial planning. In C. Rosenzweig, W. D. Solecki, S. A. Hammer, and Mehrotra, S. (eds.), *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network* (125–126). Cambridge University Press.

Bell, M. L., O'Neill, M. S., Ranjit, N., Borja-Aburto, V. H., Cifuentes, L. A., and Gouveia, N. C. (2008). Vulnerability to heat-related mortality in Latin America: A case-crossover study in São Paulo, Brazil, Santiago, Chile and Mexico City, Mexico. *International Journal of Epidemiology* **37**(4), 796–804.

Berke, P. R., Kartez, J., and Wenger, D. (1993). Recovery after disaster: Achieving sustainable development, mitigation and equity. *Disasters* **17**(2), 93–109.

Blanco, H., McCarney, P., Parnell, S., Schmidt, M., and Seto, K. C. (2011). The role of urban land in climate change. In Rosenzweig, C., Solecki, W. D., Hammer, S. A., Mehrotra, S. (eds.), *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network* (217–248). Cambridge University Press.

Braimoh, A. K., and Onishi, T. (2007). Spatial determinants of urban land use change in Lagos, Nigeria. *Land Use Policy* **24**(2), 502–515.

Capacity Development for Hazard Risk Reduction and Adaptation (CATALYST). (2013). *Before Disaster Strikes: Transformations in Practice and Policy.* CATALYST Best Practice paper on the Central America and the Caribbean region. Accessed August 20, 2015: www.catalyst-project.eu

Carter, T. R., Jones, R. N., Lu, X., Bhadwal, S., Conde, C. Mearns, L. O., O'Neill, B. C., Rounsevell, M. D. A., and M. B. Zurek. (2007). New assessment methods and the characterisation of future conditions. In Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J., and Hanson, C. E. (eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (133–171). Cambridge University Press.

City of New York. (2013). *PlaNYC: A Stronger, More Resilient New York*. Mayor's Office of the City of New York.

Comerio, M. C. (1998). *Disaster Hits Home: New Policy for Urban Housing Recover*. University of California Press.

Comisión Económica para América Latina y el Caribe (CEPAL), and Banco Inter-Americano de Desarrollo (BID), [Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IADB)]. (2007). Information for disaster risk management: Case study of five countries. Summary report. [Información para la gestión de riesgo de desastres. Estudios de caso de cinco países. Informe resumido]. Mexico City, Mexico.

Conacher Travers Pty. Ltd. (2001). *Gosford City Council Biodiversity Project: Winter–Spring 2000 Fauna Survey Component*. Local study, Gosford City Council.

de Groot, R., Wilson, M., and Boumans, R. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics* **41**, 393–408.

Department for International Development (DFID). (2005). *Disaster Risk Reduction: A Development Concern*. DFID.

Ebert, A., Welz, J., Heinrichs, D., Krellenberg, K., and Hansjürgens, B. (2010). *Socio-environmental Change and Flood Risks: The Case of Santiago de Chile* (303–313). Erdkunde.

EM-DAT: The OFDA/CRED International Disaster Database. Brussels, Belgium: Université Catholique de Louvain, Center for Research on the Epidemiology of Disasters (CRED). Accessed September 14, 2015: http://www.em-dat.net

Folke, C., Carpenter, S. R., Walker, B. H., Scheffer, M., Chapin, T., and Rockstrom, J. (2010). Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society* **15**(4), 20.

Fraser, E. D. G., Dougill, A. J., Mabee, W. E., Reed, M., and McAlpine, P. (2006). Bottom up and top down analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management* **78** (2), 114–127.

Garschagen, M., and Romero-Lankao, P. (2015). Exploring the relationships between urbanization trends and climate change vulnerability. *Climatic Change*. **133**, 37–52. doi: 10.1007/s10584-013-081-6

Gencer, E. A. (2008). *Natural Disasters, Vulnerability, and Sustainable Development*. VDM Verlag.

Gencer, E. A. (2013a). *The Interplay between Urban Development, Vulnerability, and Risk Management: A Case Study of the Istanbul Metropolitan Area*. Vol. **7**. Springer Science & Business Media. Springer Briefs in Environment, Security, Development and Peace. Heidelberg, New York, Dordrecht, London.

Gencer, E. A. (2013b). An Overview of Urban Vulnerability to Natural Disasters and Climate Change in Central America and the Caribbean Region. FEEM Nota di Lavoro 78.2013. Fondazione Eni Enrico Mattei (FEEM): Milan, Italy.

Gencer, E. A. (2014). *A Compendium of Disaster Risk Reduction Practices in Cities of the Western Balkans and Turkey*. United Nations Office for Disaster Risk Reduction (UNISDR) and World Meteorological Organization (WMO).

Gencer, E.A., Mysiak, J., and M. Breil, 2013. *Resilient City Characteristics and a Questionnaire to Assess Resiliency in Urban Areas*. Working paper. Centro Euro-Mediterraneo sui Cambiamenti Climatici: Venice, Italy. (unpublished).

Gibson, T. D., Pelling, M., Ghosh, A., Matyas, D., Siddiqi, A., Solecki, W., … and Du Plessis, R. (2016). Pathways for Transformation: Disaster Risk Management to Enhance Resilience to Extreme Events. *Journal of Extreme Events* **3**(01), 1671002.

GIZ. (2012). Disaster risk management and adaptation to climate change: Experience from German development cooperation. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Sector Project 'Disaster Risk Management in Development Cooperation'. Bonn. Accessed July 17, 2015: file:///C:/Users/SAK/Downloads/giz2012-0275en-disaster-risk-management-climate-change.pdf

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Jianguo, W., Bai, X., and Briggs, J. M. (2008). Global change and the ecology of cities. *Science* **319**(5864), 756–760.

Harlan, S. L., Brazel, A. J., Darrel Jenerette, G., Jones, N. S., Larsen, L., Prashad, L., and Stefanov, W. L. (2007). In the shade of affluence: the inequitable distribution of the urban heat island. In *Equity and the Environment* (173–202). Emerald Group Publishing Limited.

Harty, C., and Cheng, D. (2003). Ecological assessment and strategies for the management of mangroves in Brisbane water—Gosford, New South Wales, Australia. *Landscape Urban Planning* **62**, 219–240.

Hori, T. and R. Shaw. (2011). Incorporation of potential climate change impacts into local disaster risk management in Costa Rica. *Journal of Risk, Hazards and Crisis in Public Policy (RHCPP)* **2**(4). Accessed November 27, 2014: http://onlinelibrary.wiley.com/doi/10.2202/1944-4079.1094/abstract.

Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS). (2010). *Potential Impacts of Climate Change on the Hunter, Central and Lower North Coast of NSW*. Hunter Councils, NSW.

Intergovernmental Panel on Climate Change (IPCC). (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Field, C.B., Barros, V., Stocker, T. F., Qin, D., Dokken, D. J., Ebi, K. L., Mastrandrea, M. D., Mach, K. J., Plattner, G. -K., Allen, S. K., Tignor, M., and Midgley P. M. (eds.). Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). (2014a). *Climate Change 2014: Mitigation of Climate Change*. Contribution of Working Group III to the fifth assessment report of the Intergovernmental Panel on Climate Change, Annex I: Glossary. Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). (2014b). *Climate Change 2014: Synthesis Report*. Cambridge University Press.

International Recovery Platform (IRP). (2007). *Learning from Disaster Recovery Guidance for Decision Makers*. UNISDR, Geneva.

International Society of City and Regional Planning (ISOCARP). (2005). *Four Decades of Knowledge Creation and Sharing*. ISOCARP, Madrid.

Institute for Business and Home Safety (IBHS). (2002). Are we planning safer communities? Results of a national survey of community planners and natural disasters. Accessed December 8, 2014: http://www.ibhs.org/publications

Kan, H., London, S. J., Chen, G., Zhang, Y., Song, G., Zhao, N., Jiang, L., and Chen, B. (2008). Season, sex, age, and education as modifiers of the effects of outdoor air pollution on daily mortality in Shanghai, China: The Public Health and Air Pollution in Asia (PAPA) study. *Environmental Health Perspectives* **116**(9), 1183.

Kates R. W., Travis, W. R., and Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *PNAS* **109**(19), 7156–7161. doi 10.1073/pnas.1115521109

Laegdsgaard, P. (2006). Ecology, disturbance and restoration of coastal saltmarsh in Australia: A review. *Wetlands Ecological Management* **14**, 379–399.

Lewis. J. (1999). *Development in Disaster-prone Places: Studies of Vulnerability*. Intermediate Technology Publications.

Lin, B., Khoo, Y. B., Inman, M., Wang, C. H., Tapsuwan, S., and Wang, X. (2014). Assessing inundation damage and timing of adaptation: sea level rise and the complexities of land use in coastal communities. *Mitigation Adaptation Strategies Global Change* **19**, 551–568.

Magrin, G. O., Marengo, J. A., Boulanger, J. P., Buckeridge, M. S., Castellanos, E., Poveda, G., Scarano, F. R., and Vicuña, S. (2014). Central and South America. In Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., and White, L. L. (eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (1499–1566). Cambridge University Press.

Mazumder, D., Saintilan, N., and Williams, R. J. (2006). Tropic relationships between itinerant fish and crab larvae in a temperate Australian saltmarsh. *Marsh Freshwater Research* **57**, 193–199.

McGranahan, G. (2007). *Urban Environments, Wealth and Health: Shifting Burdens and Possible Responses in Low and Middle-Income Nations*. Human Settlements Working Paper, Urban Environments No. 1, International Institute for Environment and Development (IIED), London.

Mehrotra, S., Rosenzweig, C., Solecki, W. D., Natenzon, C. E., Omojola, A., Folorunsho, R., and Gilbride, J. (2011). Cities, disasters and climate risks. In Rosenzweig, C., Solecki, W. D., Hammer, S. A., and Mehrotra, Mehrotra. (eds.), *Climate Change and Cities: First Assessment Report of Climate Change Research Network* (15–42). Cambridge University Press.

Melo, O., Vargas, X., Vicuna, S., Meza, F., and McPhee, J. (2010). Climate change economic impacts on supply of water for the M & I sector in the metropolitan region of Chile. In *2010 Watershed Management Conference: Innovations in Watershed Management Under Land Use and Climate Change*, August (23–27).

Mendler de Suarez, J., Suarez, P., Bachofen, C., Fortugno, N., Goentzel, J., Gonçalves, P., Grist, N., Macklin, C., Pfeifer, K., Schweizer, S., Van Aalst, M., and Virji, H. (2012). *Games for a New Climate: Experiencing the Complexity of Future Risks*. Pardee Center Task Force Report. Boston University.

Mileti, D. S. (1999). *Disasters by Design: A Reasssesment of Natural Hazards in the United States*. Joseph Henry Press.

Millenium Ecosystem Assessment (MEA). (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press.

Mitchel, M. L., and Adam, P. (1989). The relationship between mangrove and saltmarsh communities in the Sydney region. *Wetlands (Australia)* **8**, 37–46.

Natenzon, C. E. (2005). Social vulnerability, disasters and climate change in Latin America. Thematic, theoretical and methodological approaches. In: *IIª Conferência Regional sobre Mudanças Globais: América do Sul*, San Pablo University – Brazil, November 7–10.

Natenzon, C. E., and González, S. G. (2010). Risk, social vulnerability and indicators development. Samples for Argentina [Riesgo vulnerabilidad social y construcción de indicadores. Aplicaciones para Argentina]. In *Argentina y Brasil posibilidades y obstáculos en el proceso de Integración Territorial* (195–217). Universidad de Buenos Aires.

NPCC. (2015). Building the knowledge base for climate resiliency: New York City Panel on Climate Change 2015 report Rosenzweig, C., and Solecki, W. (eds.). *Annals of the New York Academy of Sciences* **1336**, 1–149.

O'Brien, K., Eriksen, S., Nygaard, L. P., and Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy* **7**(1), 73–88.

Olhansky, R. B., and Kartez, J. D. (1998). Managing land-use to build resilience. In *Cooperating with Nature: Confronting Natural Hazards with Land-Use Planning for Sustainable Communities* (167–201). Joseph Henry Press.

Olsson, P., Galaz, V., and Boonstra, W. J. (2014). Sustainability transformations: A resilience perspective. *Ecology and Society* **19**(4), 1.

Pataki, D. E., Alig, R. J., Fung, A. S., Golubiewski, N. E., Kennedy, C. A., McPherson, E. G., Nowak, D. J., Pouyat, R. V., and Romero Lankao, P. (2006). Urban ecosystems and the North American carbon cycle. *Global Change Biology* **12**(11), 2092–2102.

Pelling, M., O'Brien, K., and Matyas, D. (2015). Adaptation and transformation. *Climatic Change* **133**(1), 113–127.

Perez, R. T. (2008). A community-based flood risk management in the lower Pampanga River basin. *Journal of Environmental Science and Management* **11**(1), 55–63.

Prabhakar, S. V. R. K., Srinivasan, A., and Shaw, R. (2009). Climate change and local level disaster risk reduction planning: Need, opportunities and challenges. *Mitigation and Adaptation Strategies for Global Change* **14**, 7–33.

Proyecto Apoyo a la Prevención de Desastres en la Comunidad Andina (PREDECAN) [Support of Disaster Prevention in the Andean Community Project]. (2009). *Articulating Risk Management and Adaptation to Climate Change in Agriculture: General Guidelines for Sector Planning and Management* [Articulando la Gestión del Riesgo y la Adaptación al Cambio Climático en el sector agropecuario: lineamientos generales para la planificación y la gestión sectorial]. Andean Community, European Commission.

Quarantelli, E. L. (1999). *The Disaster Recovery Process: What We Know and Do Not Know From Research*. Disaster Research Center.

Reddy, S. D. (2000). Factors influencing the incorporation of hazard mitigation during recovery from disaster. *Natural Hazards* **22**(2), 185–201.

Revi, A., Satterthwaite, D. E., Aragón-Durand, F. Corfee-Morlot, J., Kiunsi, R. B. R., Pelling, M., Roberts, D. C., and Solecki, W. (2014), Urban areas. In Field, C. B., V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and White, L. L. (eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.* Contribution of Working Group II to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Romero-Lankao, P. (2008). *Urban Areas and Climate Change: Review of Current Issues and Trends*. Issues paper prepared for Cities and Climate Change: Global Report on Human Settlements 2011. Accessed September 4, 2015: http://www.ral.ucar.edu/staff/prlankao-staff.php

Romero-Lankao, P. (2010). Water in Mexico City: What will climate change bring to its history of water-related hazards and vulnerabilities? *Environment Urbanization* **22**(1), 157–178.

Romero-Lankao, P., Hughes, S., Qin, H., Hardoy, J., Rosas-Huerta, A., Borquez, R., and Lampis, A. (2014). Scale, urban risk and adaptation capacity in neighborhoods of Latin American cities. *Habitat International* **42**, 224–235.

Romero-Lankao, P., and Qin, H. (2011). Conceptualizing urban vulnerability to global climate and environmental change. *Current Opinion in Environmental Sustainability* **3**(3), 142–149.

Romero-Lankao, P., Qin, H., and Borbor-Cordova, M. (2013). Exploration of health risks related to air pollution and temperature in three Latin American cities. *Social Science & Medicine* **83**, 110–118.

Romero-Lankao, P., Qin, H., and Dickinson, K. (2012). Urban vulnerability to temperature-related hazards: *A meta-analysis and meta-knowledge approach. Global Environmental Change* **22**(3), 670–683.

Rosenzweig, C., and Solecki, W. (2014). Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city. *Global Environmental Change* **28**(0),395–408.

Rosenzweig, C., Solecki, W., Hammer, S., and Mehrotra, S. (2010). Cities lead the way in climate-change action. *Nature* **467**, 909–911.

Rosenzweig, C., Solecki, W., Hammer, S., and Mehrotra, S. (eds.). (2011). *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge University Press.

Schnarwiler, R., and Tuerb, J. (2011). *Closing the Financial Gap*. Swiss Re. Accessed April 17, 2014: http://www.swissre.com/rethinking/crm/Closing_the_financial_gap.html

Senga, R. (2012). Natural or unnatural disasters: The relative vulnerabilities of South-East Asian megacities to climate change. In *Mega-Stress for Mega-Cities*. Accessed November 18, 2015: http://www.wwf.org.uk/research_centre/?3454/Mega-Stress-for-Mega-Cities

Smyth, C. G., and Royle, S. A. (2000). Urban landslide hazards: Incidence and causative factors in Niteroi, Rio de Janeiro State, Brazil. *Applied Geography*, **20**(2), 95–118.

Solecki, W., O'Brien, K., and Leichenko, R. (2011). Disaster risk reduction and climate change adaptation strategies: Convergence and synergies. *Current Opinion in Environmental Sustainability* **3**(3), 135–141.

Solecki W, Pelling M, Garschagen M. (2017). A framework for urban risk management regime shifts. Ecology & Society. 22(2): 38.

Steinberg, M., and Burby, R. (2002). Growing safe. *Planning* (April), 22–23.

Stewart, M. G., Wang, X., and Willgoose, G. R. (2014). Direct and indirect cost and benefit assessment of climate adaptation strategies for extreme wind events in Queensland. *Natural Hazards Review* **15**(4), 04014008. Accessed May 24, 2015: http://dx.doi.org/10.1061/(ASCE)NH.1527–6996.0000136

Swiss Re. (2013). *Natural catastrophes and man-made disasters in 2012: A year of extreme weather events in the U.S. Sigma 2013/2*. Author.

Thomalla, F., et al. (2006). Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation. *Disasters* **30** (1), 39–48.

Tourism Research Australia. (2007). Tourism profiles for local government areas in regional Australia, New South Wales, City of Gosford. Accessed May 26, 2014: http://www.ret.gov.au/tourism/Documents/tra/local%20government%20area%20profiles/Gosford%20LGA.pdf

Tran, P., and Shaw, R. (2007). Towards an integrated approach of disaster and environmental management: A case study of Thua Thien Hue province in central Vietnam. *Environmental Hazards* **7**(4), 271–282.
Tyler, S., and Moench, M. (2012). A framework for urban climate resilience. *Climate and Development* **4**.4(2012), 311–326.
United Nations (UN). (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. Third UN World Conference on Disaster Risk Reduction. Sendai, Japan. A/CONF.224/CRP.1. Accessed May 18, 2016: http://www.wcdrr.org/
United Nations Department of Economic and Social Affairs (UN-DESA). (2015). *World Urbanization Prospects*, United Nations.
United Nations Development Programme (UNDP). (2004). *Reducing Disaster Risk: A Challenge for Development*. Accessed August 10, 2015: http://www.undp.org/bcpr
United Nations Human Settlements Programme (UN-Habitat). (2003). The Challenge of Slums. Global Report on Human Settlements. Earthscan. London.
United Nations Human Settlements Programme (UN-Habitat). (2011). *Global Report on Human Settlements: Cities and Climate Change*. Earthscan.
United Nations International Strategy for Disaster Reduction (UNISDR). (2007). *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters*. United Nations.
United Nations International Strategy for Disaster Reduction (UNISDR). (2009). *2009 UNISDR Terminology on Disaster Risk Reduction*. United Nations.
United Nations International Strategy for Disaster Reduction (UNISDR). (2011). *2011 Global Assessment Report on Disaster Risk Reduction*. UNISDR.
UNISDR Urban Planning Advisory Group (UPAG). (2015). *Eight Frequently Asked Questions on DRR and Urban Planning*. Prepared for the Third UN World Conference on Disaster Risk Reduction, Sendai, Japan. (unpublished).
United States (U.S.) Census. (2010).
Vazquez-Brust, D., Plaza Ubeda, J. A., de Burgos Jiménez, J., and Natenzon, C. E. (eds.). (2012). *Business and Environmental Risks: Spatial Interactions between Environmental Hazards and Social Vulnerabilities in Ibero-America*. Springer.
Vignola, R., Locatelli, B., Martinez C., and Imbach, P. (2009). Ecosystem-based adaptation to climate change: What role for policy-makers, society and scientists? *Mitigation and Adaptation Strategies for Global Change* **14**, 691–696.
von Peter, G., von Dahlen, S., and Saxena, S. C. (2012). *Unmitigated Disasters? New Evidence on the Macroeconomic Cost of Natural Catastrophes*. Bank for International Settlements (BIS). Accessed September 3, 2015: http://www.bis.org/publ/work394.htm
Vorhies, F. (2012). *The Economics of Investing in Disaster Risk Reduction*. UNISDR Working Paper. UNISDR.
Wang, X., Khoo, Y. B., and Wang, C. H. (2014). Risk assessment and decision-making for residential housing adapting to increasing storm-tide inundation due to sea level rise in Australia. *Civil Engineering and Environmental Systems* **31**(2), 125–139.
Warner, K., et al. (2009). In search of shelter: Mapping the effects of climate change on human migration and displacement. CARE.
Wisner, B., et al. (2004). *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. 2nd ed. Routledge.
World Bank (WB). 2012. *Improving the Assessment of Disaster Risks to Strengthen Financial Resilience*. World Bank. Accessed August 15, 2014: http://documents.worldbank.org/curated/en/2012/01/16499055/improving-assessment-disaster-risks-strengthen-financial-resilience
World Bank (WB) and the Global Facility for Disaster Reduction and Recovery (GFDRR). (2010). *Disaster Risk Management in Latin America and the Caribbean Region: GFDRR Country Notes*. World Bank.
Yasui, E. (2007). *Community Vulnerability and Capacity in Post-disaster Recovery: The Cases of Mano and Mikura Neighbourhoods in the Wake of the 1995 Kobe Earthquake*. University of British Columbia.

Chapter 3 Case Study References

Case Study 3.1 The Boulder Floods: A Study of Urban Resilience

City of Boulder Flood Management Program (2014).City of Boulder. Accessed February 8, 2015: https://www-static.bouldercolorado.gov/docs/flood-management-program-overview-1–201410060951.pdf
Peel, M. C., Finlayson, B. L., and McMahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences Discussions* **4**(2), 462.
World Bank. (2017). 2016 GNI per capita, Atlas method (current US$). Accessed August 9, 2017: http://data.worldbank.org/indicator/NY.GNP.PCAP.CD

Case Study 3.2 Adaptation to Flooding in the City of Santa Fe, Argentina: Lessons Learned

Cardoso, M. M. (2011). Impacto ambiental de los nuevos procesos urbanos en el área metropolitana de Santa Fe [Environmental impact of the new urban processes in the Santa Fe Metropolitan Area].*V Congreso Iberoamericano sobre Desarrollo y Ambiente de REDIBEC /V Jornadas de la Asociación Argentina Uruguaya de Economía Ecológica*. Santa Fe, Facultad de Ingeniería y Ciencias Hídricas, Universidad Nacional del Litoral; 12 a 14 de setiembre. Accessed September 14, 2014: http://fich.unl.edu.ar/CISDAV/upload/Ponencias_y_Posters/Eje08/Maria_Mercedes_Cardoso/V%20CISDA%20Trabajo%20completo%20Impacto.pdf
CEPAL – United Nations. (2003). *Evaluación del impacto de las inundaciones y el desbordamiento del río Salado en la provincia de Santa Fe, República de Argentina en 2003*. [Assessing the impact of flooding and overflow of the Salado River in the province of Santa Fe, Republic of Argentina in 2003]Buenos Aries, LC/BUE/R.254, Buenos Aries, CEPAL, LC/BUE/R.254, Restricted Distribution 89 p. Accessed October 14, 2014: http://repositorio.cepal.org/bitstream/handle/11362/28461/LCbueR254_es.pdf?sequence=1/
Demographia. (2016). *Demographia World Urban Areas 12th Annual Edition: 2016:04*. Accessed August 9, 2017: http://www.demographia.com/db-worldua.pdf
Disaster Relief Emergency Fund (DREF). (2008). *Argentina: Foods*. International Federation of Red Cross and Red Crescent Societies, DREF operation n° MDRAR002. GLIDE n°FL-2007–000044-ARG, 8 May 2008. Accessed October 14, 2014: http://www.ifrc.org/docs/appeals/rpts08/MDRAR002final.pdf
Gobierno de la Ciudad de Santa Fe. (2011). Premio Sasakawa de las Naciones Unidas Gestión de Riesgos (UN Sasakawa Award 2011). Accessed June 3, 2014: http://santafeciudad.gov.ar/blogs/gestionderiesgos/premio-sasakawa-de-las-naciones-unidas/
Gobierno de la Ciudad de Santa Fe. (2015). *Datos Generales [General Data]*. Accessed February 29, 2016: http://www.santafeciudad.gov.ar/ciudad/datos_generales/poblacion.html
INDEC. (2015). *Censo Nacional de Población 2010. In: Base de datos Redatam+Sp*. Accessed February 29, 2016: http://200.51.91.245/argbin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=CPV2010B&MAIN=WebServerMain.inl
Peel, M. C., Finlayson, B. L., and McMahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences Discussions* **4**(2), 462.
Viand, J. (2009). Before the disaster. Social risk construction and the flood of 2003 in Santa Fe city. Bachelor´s thesis, University of Buenos Aires.
World Bank. (2017). 2016 GNI per capita, Atlas method (current US$). Accessed August 9, 2017: http://data.worldbank.org/indicator/NY.GNP.PCAP.CD

Case Study 3.3 Preparedness, Response, and Reconstruction of Tacloban for Super Typhoon Haiyan in The Philippines

Philippine Statistics Authority. (2014). Leyte Province. Municipalities and cities. Accessed March 24, 2015: http://www.nscb.gov.ph/activestats/psgc/province.asp?regName=REGION+VIII+%28Eastern+Visayas%29&regCode=08&provCode=083700000&provName=LEYTE

Philippine Statistics Authority (2016). Population of Population of Region VIII – Eastern Visayas (Based on the 2015 Census of Population) Accessed June 28, 2017: http://psa.gov.ph/content/population-region-viii-eastern-visayas-based-2015-census-population

Philippine Government. (2013). Reconstruction Assistance on Yoland – Building Back Better.

World Bank. (2017). 2016 GNI per capita, Atlas method (current US$). Accessed August 9, 2017: http://data.worldbank.org/indicator/NY.GNP.PCAP.CD