4

Integrating Mitigation and Adaptation

Opportunities and Challenges

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Integrating Mitigation and Adaptation: Opportunities and Challenges

Urban planners and decision-makers need to integrate efforts to mitigate the causes of climate change (mitigation) and adapt to changing climatic conditions (adaptation), for a global transition to a low-emissions economy and a resilient world. Actions that promote both goals provide win-win solutions. In some cases, however, decision-makers have to negotiate tradeoffs and minimize conflicts between competing objectives.

A better understanding of mitigation, adaptation, resilience and low-emissions development synergies can reveal greater opportunities for their integration in urban areas. For example, strategies that reduce the UHI effect, improve air quality, increase resource efficiency in the built environment and energy systems, and enhance carbon storage related to land use and urban forestry are likely to contribute to greenhouse gas (GHG) emissions reduction while improving a city's resilience. The selection of specific adaptation and mitigation measures should be made in the context of other Sustainable Development Goals by taking into account current resources and technical means of the city, plus the needs of citizens.

Major Findings

- Mitigation and adaptation policies have different goals and opportunities for implementation. However, many drivers of mitigation and adaptation are common, and solutions can be interrelated. Evidence shows that broad-scale, holistic analysis and proactive planning can strengthen synergies, improve cost-effectiveness, avoid conflicts, and help manage trade-offs.

- Diagnosis of climate risks and the vulnerabilities of urban populations and territory is essential. Likewise, cities need systematic GHG emissions inventories and emission reduction pathways in order to prepare mitigation actions.

- Contextual conditions determine a city's challenges, as well as its capacity to integrate and implement adaptation and mitigation strategies. These include the environmental and physical setting, the capacities and organization of institutions and governance, economic and financial conditions, and sociocultural characteristics.

- Integrated planning requires holistic, systems-based analysis that takes into account the quantitative and qualitative costs and benefits of integration compared to stand-alone adaptation and mitigation policies. Analysis should be explicitly framed within city priorities and provide the foundation for evidence-based decision support tools.

Key Messages

Integrating mitigation and adaptation can help avoid locking a city into counterproductive infrastructure and policies. Therefore, city governments should develop and implement climate action plans early in their administrative terms. These plans should be based on scientific evidence and should integrate mitigation and adaptation across multiple sectors and levels of governance. Plans should clarify short-, medium-, and long-term goals; implementation opportunities; budgets; and concrete measures for assessing progress.

Integrated city climate action plans should include a variety of mitigation actions (involving energy, transport, waste management, and water resources) and adaptation actions (involving infrastructure, natural resources, health, and consumption, among others) in synergistic ways. Because of the comprehensive scope, it is important to clarify the roles and responsibilities of key actors in planning and implementation. Interactions among the actors must be coordinated during each phase of the process.

Once priorities and goals have been identified, municipal governments should connect with federal legislation, national programs, and, in the case of low-income cities, with international donors in order to implement actions and foster helpful alliances and financial support.

4.1 Introduction

This chapter presents the challenges and opportunities related to the integration of adaptation and mitigation policies and practices in cities. The objective is to guide decision-makers, urban planners, and practitioners toward opportunities and challenges of integrated climate change planning. This is done by means of a literature review of mitigation and adaptation relationships and by presenting examples from selected cities to discover best practices with regard to integrated solutions. The chapter shows how urban planners and decision-makers can enhance synergies, negotiate tradeoffs, and minimize conflicts between adaptation and mitigation.

The focus of the chapter is threefold. First, we present relationships between adaptation and mitigation, which are now understood as encompassing low emissions development and resilience across different urban sectors, and we identify synergies and conflicts on the policy level. After introducing the integration of mitigation and adaptation (*Ad-Mit* and *Mit-Ad*, respectively – adaptation actions with mitigation effects, and, conversely, mitigation positively affecting adaptation), we show real-world examples of synergies and conflicts in selected city Case Studies. Finally, we discuss how a better understanding of the integration of mitigation and adaptation can provide opportunities for urban areas, but challenges as well.

Table 4.1 presents urban examples of potential adaptation and mitigation synergies, tradeoffs, and conflicts cutting across sectors. These illustrate the scales at which integration issues must be addressed. Learning from experience is an important element in understanding the necessary steps toward a successful process of implementation of climate change planning and management.

4.2 Climate Mitigation and Adaptation in the Urban Context

As of 2014, 54% of the world's population resided in urban areas, compared to 30% in 1950 and 66% projected for 2050 (UNDESA, 2014). Cities are major contributors to global greenhouse gas (GHG) emissions and, due to large population concentrations, also highly vulnerable to climate change impacts such as heat waves, floods, severe storms, and droughts (Sims and Dhakal, 2014; Fischedick et al., 2012; Lucon et al., 2014; Revi et al., 2014; Balaban and de Oliveira, 2013). Cities are at the forefront of climate policies (Rosenzweig et al., 2011), and the need for decision-makers and planners to respond to climate change is crucial for collaborative urban climate governance (Bulkeley, 2013) (see Box 4.1) (see Chapter 16, Governance and Policy).

Responses to climate change in cities consist of the design and implementation of policies and practices to reduce anthropogenic GHG emissions, known as *mitigation measures*, and responses to climate-related impacts and risks, known as *adaptation measures*. For mitigation planning, the primary goal is to reduce current and future direct and indirect GHG emissions, particularly from energy production, land use, waste, industry, the built environment infrastructure, and transportation. The primary goal of adaptation is to adjust the built, social, and ecological environment to minimize the negative impacts of both slow-onset and extreme events caused by climate change, such as sea-level rise, floods, droughts, storms, and heat waves.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) chapters covering the relationships between adaptation and mitigation raised the importance of examining possibilities for integration of adaptation and mitigation policies and foundations for decision-making (Klein et al.,

Table 4.1 *Main differences between mitigation and adaptation. Source: Adapted from Dang et al., 2003*

	MITIGATION POLICY	ADAPTATION POLICY
Sectoral focus	All sectors that can reduce GHG emissions	Selected at-risk sectors
Geographical scale of effect	Global	Local, regional
Temporal scale of effect	Long term	Short, medium, and long term
Effectiveness	Reduction in global temperature rise commitment	Increases in climate resilience
Ancillary benefits (or co-benefits)	Multiple	Improved response to extreme events in current climate
Actor benefits	Through ancillary benefits	Almost fully through reduction of climate impact and ancillary benefits
Polluter pays	Yes	Not necessarily
Monitoring	Relatively easy (measuring the reduction of greenhouse gas emissions)	More difficult (measuring the reduction of climate risk)

Box 4.1 Cities' Commitment to Tackle Climate Change

By signing the Global Cities Covenant on Climate – known as the Mexico City Pact – in November 2010, mayors and municipal authority representatives demonstrated their voluntary commitments on the frontline of climate change response. Furthermore, climate finance for city governments is highlighted in the Nantes Declaration of Mayors and Subnational Leaders on Climate Change that was adopted in 2013. These city agreements and the culture of fostering city-to-city cooperation take a number of forms at different levels. The Global Covenant of Mayors for Climate & Energy (2016), the ICLEI–Local Governments for Sustainability, United Cities and Local Governments (UCLG), C40 Cities Climate Leadership Group, World Mayors Council on Climate Change, and World Association of the Major Metropolises are among the organizations that are convening city authorities to act against climate change. In October 2014, the Mayors Adapt Signature Ceremony in Brussels gathered more than 150 city and regional authority representatives committed to European initiatives on adaptation to climate change (European Climate Adaptation Platform, 2014). The leadership of cities in combatting climate change and advancing energy efficiency and renewable energy use is the subject of the Earth Hour City Challenge contest that the World Wildlife Fund (WWF) launched in 2013, awarding a city each year for its outstanding achievements (i.e., Vancouver in 2013, Cape Town in 2014, and Seoul in 2015). The Climate Summit for Local Leaders at Paris City Hall on December 4, 2015, brought to the fore the strength of the commitment made by city actors in the fight against climate change. The Paris Agreement secured at COP21 places the involvement of non-state actors on the cutting edge of research toward and implementation of climate solutions.

2007; Jones et al., 2007). The Fifth Assessment Report (AR5) of the IPCC addressed urban issues directly through chapters on adaptation in urban areas and mitigation in human settlements, infrastructure, and spatial planning but also indirectly through the subjects of integrated risk and uncertainty assessment of climate policies as well as sectoral chapters on topics such as buildings and transport (Revi et al., 2014; Seto and Dhakal, 2014; Kunreuther et al., 2014; Lucon et al., 2014; Sims et al., 2014).

The dichotomy between mitigation and adaptation is rooted in history (Pacteau and Joussaume, 2013). Mitigation has been considered a global-scale issue, whereas adaptation is seen as local. Furthermore, in the first years after the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), mitigation issues had more importance politically, whereas adaptation is a newer issue to be dealt with. Yet, because the impacts of climate change are already being felt across the world, the role and associated responsibilities of both mitigation and of adaptation have been reconsidered. The need for future balance between adaptation and mitigation has led to a search for integrated climate policies across scales. The importance of bottom-up action is recognized along with increasing acceptance of the important role of cities, metropolises, and other subnational territories. Municipal authorities in cities and urban areas across the world have been driven to find ways to mitigate GHG emissions and seek innovative strategies to adapt to climate change based on individual capacities and networks (see Box 4.1).

4.3 Integrating Mitigation and Adaptation

A growing body of scientific evidence demonstrates the importance of implementing mitigation and adaptation in an integrative manner. This literature analyzes adaptation and mitigation relationships on a more conceptual level and provides in-depth empirical analyses and case studies of best practices in different cities, applying a range of qualitative and quantitative methods (Landauer et al., 2015). In the literature, the interrelationships are typically conceptualized as synergies and conflicts between the two climate policies or tradeoffs in cases where a balance is being sought (Klein et al., 2007). Based on the empirical evidence, mitigation policies such as promotion of energy-efficient technologies and actions for energy savings and efficiencies have traditionally been introduced by national governments and targeted toward specific sectors such as industry, power generation, transportation, and construction. Adaptation policies are newer on the agenda, particularly at the subnational level (de Oliveira, 2009). Ayers and Huq (2009) point out that the predominant focus on mitigation actions in vulnerable developing countries has hindered their engagement in adaptation due to lack of financial incentives.

Examining adaptation and mitigation in an integrated manner is considered particularly important at the city scale (McEvoy et al., 2006; Saavedra and Budd, 2009). This is so because the benefits of integration of the two policies can best be seen at the city level. Additionally, the integration of mitigation and adaptation has the potential to reduce the costs of emissions that influence urban climates, and adaptation helps cities prepare for both slow-onset and extreme events of climate change (Callaway, 2004). Especially in urban areas, integrated solutions can help avoid maladaptation and realize Sustainable Development Goals (Barnett and O'Neill, 2010; Döpp et al., 2010). The Case Studies in this chapter serve as an evidence base from cities in different geographical regions and contexts. However, it should be kept in mind that an action implemented in one place does not necessarily mean that it is suitable for another.

In terms of urban climate governance, the complex interactions of different actors, sectors, and scales make implementation of climate policies particularly challenging (see Chapter 16, Governance and Policy). Despite the complexity originating from the multiscale dynamics in urban areas, the integration of adaptation and mitigation strategies can succeed (Thornbush et al., 2013). City administrations have responsibility for both adaptation and mitigation, but climate policies at the city scale cannot be completely separated from their national and global contexts – or from the private sector (Hall et al., 2010; Swart and Raes, 2007). The costs and benefits of adaptation and mitigation and allocation of responsibilities to implement policies vary across urban sectors and levels of governance, which complicates planning and decision-making in cities (Piper and Wilson, 2009). Dual consideration explicitly takes into account the cross-sectoral and cross-scale nature of adaptation and mitigation.

4.3.1 Differences between Adaptation and Mitigation across Multiple Scales and Sectors

A dichotomy between adaptation and mitigation policies arises from a number of factors; these include differences in spatial, temporal, institutional, and administrative scales, as well as differences in research traditions and disciplines (Moser, 2012; Goklany, 2007; Swart and Raes, 2007; Wilbanks et al., 2007; Dymén and Langlais, 2013). The integration of adaptation and mitigation is often discussed in such a scale-related context. In the case of mitigation, the main focus is global and national, whereas in the case of adaptation, it is local and territorial scales. Time frames also differ since mitigation is considered a long-term process, whereas adaptation often implies short-term actions ranging from seasonal to decadal (see Table 4.1). Adaptation also reduces pre-existing vulnerabilities to climate extremes that exist even without climate change.

In addition, the governance of adaptation and mitigation is placed at different jurisdictional and institutional scales, characterized by vertical or horizontal modes of governance, and different actors and their interactions (Kern et al., 2008) (see Chapter 16, Governance and Policy). Sometimes adaptation and mitigation are not separated in scale-based dichotomies but instead are considered on "continuous" scales: municipal to national, short-term to long-term, and local to global (Dymén and Langlais, 2013; Dantec and Delebarre, 2013). To identify the interrelationships between adaptation and mitigation, it is advantageous to have information on the scales at which the policy development is driven, how the policies transect one another,

Box 4.2 Linking Adaptation and Mitigation and the Prospects for Transformation

Notwithstanding the extent of the challenge, the importance of concerted and holistic action on climate and other forms of environmental change has recently been underscored in the global arena by the inclusion of such action as a specific target within the urban Sustainable Development Goal (Goal 11). Additional target 11.b states:

> By 2030, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels.

This is intended to promote appropriate collaborative actions by national, regional, and city governments to promote urban sustainability.

Mitigation and adaptation interventions of all categories have particular cost and impact thresholds, from the proverbial low-hanging fruit yielding positive returns to expensive capital-intensive solutions that may provide only modest benefits that challenge their value. Incremental change and reform therefore have limitations. Partly in consequence, attention has recently been drawn increasingly to the actual or potential limitations of even integrated action on mitigation and adaptation where this is unlikely to be adequate to overcome manifestly unsustainable urbanism (Pelling, 2011, Pelling et al., 2012; Simon and Leck, 2015). The reasons for this could be many, including where the magnitude of forecast climate change will demand dramatic changes to the urban fabric, where biophysical or environmental constraints in arid and semi-arid regions will occur, and where obsolete built environments and infrastructure or highly polarized societies reflecting strongly unequal power relations present strong constraints to change.

Transformation was defined in Chapter 1 as *a fundamental change to the status quo and its underlying social-ecological relations or, in urban contexts, to the nature of the built environment and how it is used*. With respect to tackling the impacts of climate change, long-term unsustainability would arise where conventional mitigation and adaptation interventions, even as part of a holistic strategy, would prove inadequate in preventing inundation, desertification, or the persistence of widely uninhabitable conditions. Rising sea levels and the growing frequency and intensity of storms on the one hand and the changing frequency and intensity of rainfall in many regions on the other present different challenges to coastal and inland cities alike.

The profound upgrading of response and recovery strategies – as well as preventative measures – provoked in New Orleans by Hurricane Katrina and in metropolitan New York by Hurricane Sandy are instructive, but cities and societies with limited resources would be overstretched by such measures (Rosenzweig and Solecki, 2014; Solecki, 2015). There will be low-lying areas, for instance, that cannot be protected from frequent inundation, and steep-sloped neighborhoods may be rendered uninhabitable or their infrastructure unusable by floods and landslides.

This will necessitate profoundly difficult decisions about possible abandonment of such areas and organized resettlement of the inhabitants elsewhere. Although this provides opportunities to design or redesign substantial areas in accordance with new sustainability principles, with implications for the town or city as a whole in terms of overall sustainability, it will also require massive investment as well as more flexible and appropriate building, planning, and zoning regulations than are currently in place in most urban areas worldwide.

and where the policies are implemented (Landauer et al., 2015). Laukkonen et al. (2009) point out that development of tools and procedures is needed that can help actors at different scales find best practices for adaptation, mitigation, and their integration.

In urban planning practice, a few key scale-related differences exist between adaptation and mitigation. Both policies are driven by *institutional-scale* factors such as laws and regulations to support policy decisions and operating rules to govern climate change in cities. The institutional complexity makes implementation of adaptation actions more challenging compared to mitigation actions due to the great variety of sectors and actors involved (McEvoy et al., 2006).

In addition, the focus of the policy decisions and strategies differ: in the case of adaptation, they tend to be more city- and regional-level initiatives because the impacts of climate change depend on the likelihood of risk outcomes at a smaller scale, whereas for mitigation emissions, reduction should take place globally. In regard to *spatial scale*, the benefits of mitigation accrue globally, whereas the benefits of adaptation tend to aggregate at city and regional scales, encouraging policies ranging from the regional scale to even the building scale (Ayers and Huq, 2009; Balaban and de Oliveira, 2013).

In terms of the *temporal scale* – due to feed-forward delays in the carbon cycle in the atmosphere – benefits from mitigation measures are realized over longer time scales, while adaptation has more short-term effects by reducing vulnerability to immediate and near-term climate risks (McEvoy et al., 2006; IPCC, 2007; Ayers and Huq, 2009) (see Figure 4.1) (see Chapter 2, Urban Climate Science, and Chapter 3, Disasters and Risk).

Furthermore, mitigation costs are typically local – although benefits are mainly global (although reductions in energy costs can be also local) – whereas adaptation costs and benefits tend to be localized (Jones et al., 2007; Ayers and Huq, 2009). An exception is where the benefits of adaptation can also be seen globally through reduction of threats to natural systems (Goklany, 2007) (see Chapter 8, Urban Ecosystems). Moreover, mitigation co-benefits (or ancillary benefits) are often local, especially in cases where reduction of emissions leads to, for example, improvements in air quality, public health, or improved transportation systems (IPCC, 2007) (see Table 4.1). This is particularly relevant for cities since the search for an optimum planning and policy balance between mitigation and adaptation is to a large extent contingent upon capturing positive co-benefits and avoiding policy conflicts.

Mitigation and adaptation policy formation and implementation are conducted at different *jurisdictional scales*. Adaptation is the responsibility of mainly municipal-, provincial-, and national-level administrations, whereas national governments and supranational institutions are the legal governing institutions for mitigation actions (Ayers and Huq, 2009; Ford et al., 2011). However, in some countries, mitigation actions, laws, and policies have been adopted and implemented at the city level long before such measures or policies were adopted at the national level. These municipal mitigation actions and policies were commonly attributed to urban sectors – such as transportation, water management, and waste management – delivering urban development benefits simultaneously (see Case Study 4.6). Some authors suggest that the optimal combination of mitigation and adaptation depends on the magnitude of the climate impacts within each management jurisdiction (Saavedra and Budd, 2009; Jones et al., 2007).

Cities and municipal governments have different incentives, motivations, and dynamics for mitigating GHG emissions (as well as different beneficiaries of actions) than do national governments. For several reasons, city governments also apply GHG

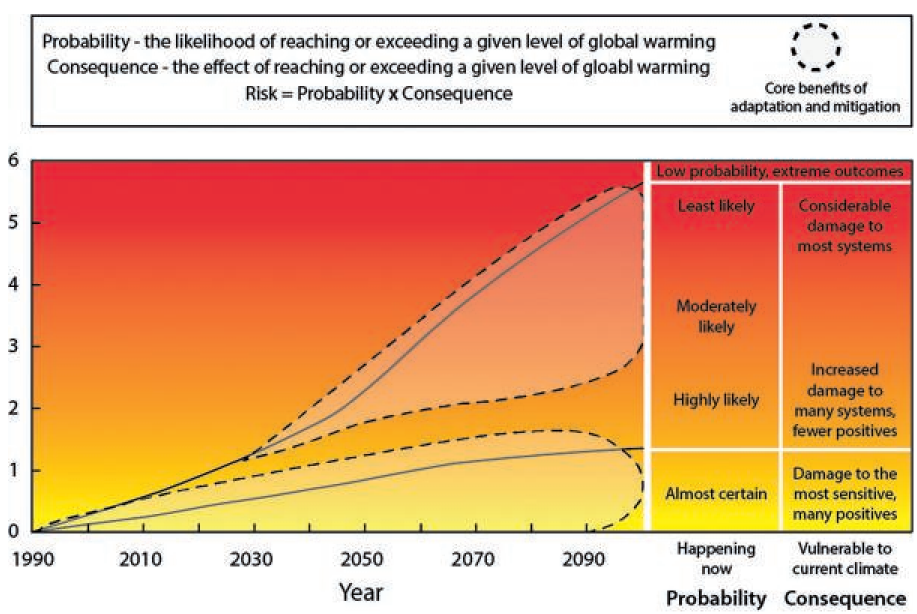


Figure 4.1 *Illustrative benefits and risks of climate policies, according to projected ranges of global warming.*

Source: Jones et al., 2004; Jones and Yohe, 2008 mitigation metrics that are different from national ones: lack of disaggregated data, leakages and spillover effects, and drivers for sectoral action (e.g., decarbonized transportation modes, energy-efficient appliances and equipment, "green" buildings). Very often municipal and regional actors work independently of the national governments and multilateral climate agreements since they are more influenced by the considerations of local civil society. However, in recent years – particularly after the COP16 in Cancun, 2010 – subnational governments have strived more intensely to be recognized as important players and to take an active role in the international climate change decision-making framework within the UNFCCC. This has resulted in the explicit negotiation of the role of cities in the Paris Agreement of COP21.

4.3.2 Adaptation and Mitigation Measures across Different Sectors

In urban areas, *adaptation* measures are implemented through urban planning and management sectors that focus mainly on zoning, building codes, water quality, flood protection, and surface runoff management (see Table 4.2). Adaptation also includes measures that increase the indoor climate comfort of buildings – such as heating, ventilation, and air conditioning (HVAC) and cool roofs (white and green) that address the UHI (McEvoy et al., 2006) (see Chapter 2, Urban Climate Science) – as well as green (vegetation, permeable surfaces) and blue (bodies of water) measures to increase climatic comfort, control flooding, and enhance urban biodiversity. In general, adaptation

Table 4.2 *Examples of synergies and conflicts between adaptation and mitigation*

Climate Policy	Practical measures by sectors	Examples of synergies between adaptation and mitigation	Examples of conflicts between adaptation and mitigation	Examples of sectors affected by implementation of measures	Source
	Building and Infrastructure				
Mitigation	Building orientation, height and spacing	Reduced need for conventional air-conditioning		Urban Planning, Health and Security, Energy	Barbhuiya et al. (2013)
Adaptation	Urban greening and green infrastructure practices	Carbon sequestration and reduction of heat stress, air pollution and flooding	High space demand	Urban Planning, Agriculture, Forest and Biodiversity (AFB), Water Management, Health and Security	Thornbush et al. (2013)
Adaptation	Ventilation and air-conditioning	Passive cooling combined with night ventilation	High energy demand	Energy, Health and Security	Gupta and Gregg (2013)
	Water Management				
Adaptation	Open storm water systems via urban wetlands		High space demand	AFB, Health and Security, Urban Planning	Laukkonen et al. (2009)
Adaptation	Water pumping to control flooding		High energy demand	Energy, Building and Infrastructure	Sugar et al. (2013)
Adaptation	Flood protection walls, dams, etc.		Emissions through material production and construction, biodiversity loss	Energy, AFB, Building and Infrastructure	Kenway et al. (2011)
Adaptation	Water saving	Reduction of energy use for water treatment/extraction		Energy, Infrastructure	Kenway et al. (2011)
	Urban Planning				
Mitigation	Urban densification		More built mass, less urban drainage, heat gains, storm water and flood risks, discomfort and health risks, more emissions from transportation, water pollution via poorly planned dense cities	Energy, Water Management, Health and Security, Transportation, AFB	Dymen and Langlais (2013); Hamin and Gurran (2009)

Table 4.2 (*continued*)

Climate Policy	Practical measures by sectors	Examples of synergies between adaptation and mitigation	Examples of conflicts between adaptation and mitigation	Examples of sectors affected by implementation of measures	Source
	Energy				
Mitigation	Solar, wind, and wave energy	Reduction of risks of widespread power loss or peak power loads under storm events and temperature extremes		Building and Infrastructure, Health and Security	Hamin and Gurran (2009); Laukkonen et al. (2009); McEvoy et al. (2006); Sugar et al. (2013)
	Transportation				
Mitigation	Multimodal and public transportation	Synergy if built along urban green corridors*		Energy, Health and Security	Sugar et al. (2013); Thornbush et al. (2013)

**Note:* Urban green corridors are networks of green areas within the city and its surroundings. In addition to adaptation and mitigation functions (e.g., flood protection, carbon capture and storage, and surface temperature regulation), they provide many other benefits such as recreation and biodiversity protection.

measures are more difficult to retrofit over existing settlements than to implement in new areas.

Furthermore, adaptation of vulnerable sectors such as agriculture, forestry, and coastal zone management are often interlinked with urban decision-making. There is a growing body of literature highlighting the importance of urban and peri-urban linkages, particularly with regard to the agriculture and forestry sectors. Lwasa et al. (2014) emphasize the role of urban and peri-urban agriculture and forestry (UPAF) both in climate mitigation and adaptation. UPAF contributes to mitigation through the sequestration of carbon and by reducing the carbon emissions of food systems through the reduction of transport-related emissions for food consumption in cities. These UPAF contributions to adaptation come through the promotion of urban food security.

Mitigation measures cover efficiency, fuel decarbonization, and carbon recovery in sectors such as energy production, industry, buildings, infrastructure, transportation, waste management, and land use (see Table 4.2). In the energy sector, efficiency and decarbonization are important issues: consumption can be reduced for the same output, renewable sources can be substituted, and smart technologies can reduce emissions either directly or indirectly. Moreover, behavioral change can reduce demand and lifestyle-related impacts. In the transportation sector, low-carbon fuels, advanced technologies, efficient transport modes, and adequate planning can ensure efficiency and reduce dependency of fossil fuels. Urban infrastructure can be more efficient from a mitigation perspective, benefiting from densification of urban structure and multiple centers, as well as from public and non-motorized transportation. In the building sector, energy efficiency requirements and the resulting GHG mitigation goals can be achieved by means of several measures (design, materials, envelope, "greening," and albedo), where in many cases passive technologies are advantageous (McEvoy et al., 2006; Gupta and Gregg, 2013; Barbhuyia et al., 2013; Lucon et al., 2014) (see Chapter 5, Urban Planning and Design). Municipal solid waste management measures include reuse and recycling programs, utilizing energy from methane in landfills, and waste-to-energy systems.

There are adaptation measures that also can be considered as mitigation (*Ad-Mit*) – for instance, white roofs and other reflective surfaces installed to primarily improve dwellers' thermal comfort but as a co-benefit mitigate global warming by reducing the solar energy (radiative forcing W/m^2 over a period) absorbed by the surface. Other measures can be considered as primarily for mitigation, with adaptation co-benefits (*Mit-Ad*) – for example, carbon sequestration by trees reducing the UHI effect; passive or zero-energy building designs that simultaneously save energy and improve comfort; and the use of improved fuel wood cook stoves reducing the pressure for deforestation in ecologically sensitive areas.

4.3.3 Synergies, Conflicts, and Tradeoffs between Adaptation and Mitigation across Urban Sectors and Scales

Climate change adaptation and mitigation measures are interrelated – in some cases positively (synergies), in others negatively (conflicts) – and sometimes decisions on implementation are based on difficult tradeoffs, thus necessitating choices between conflicting policy and planning goals (Klein et al., 2007). For the purposes of this chapter, a *synergy* is understood as an interaction between an adaptation and a mitigation plan, policy, strategy, or practical measure that produces an effect greater than the constituent components. A *conflict* is a plan, policy, strategy, or practical measure that counteracts or undermines one or more planning goals between adaptation and mitigation. Finally, a *tradeoff* is a situation that necessitates choosing (balancing) between one or more desirable, but sometimes conflicting, plans, policies, or strategies. Table 4.3 presents a list of real examples of cases where adaptation and mitigation integration happened (of which further details are provided in Case Studies 4.1–4.6).

Key issues are structured around four basic questions:

1. What types of interrelationships can be identified (synergies, conflicts, tradeoffs)?
2. Where do the interrelationships originate (drivers)?
3. Across which sectors do they typically cut (cross-sectoral interactions)?
4. Where can examples of integrated implementation be found (geographical location)?

Synergies between adaptation and mitigation can be found in the building sector (Barbhuiya et al., 2013; Gupta and Gregg, 2013; McEvoy et al., 2006) (see Chapter 5, Urban Planning and Design). In order to increase the indoor climate comfort of buildings while simultaneously reducing energy use, passive designs, changed behavioral measures, and more advanced technologies can be utilized for heating, cooling, and ventilation (Thornbush et al., 2013; Gupta and Gregg, 2013; Lucon et al., 2014). Adequate orientation and morphology of buildings and streets also target adaptation and mitigation in an integrated manner (Barbhuiya et al., 2013; Mills et al., 2010). House insulation and introduction of solar collectors for heating water increase energy efficiency and reduce related CO_2 emissions while at the same time increasing resilience to temperature changes (Barbhuyia et al., 2013). Furthermore, while ensuring energy efficiency of buildings by selection of materials and location of buildings, at the same time buildings should be resistant to heat waves, floods, and humidity.

Europe has faced exceptionally warm summers, such as the record years 2003 and 2010 have shown, and the probability of a summer experiencing mega heat waves is considered to increase by a factor of 5–10 within the next forty years (Barriopedro et al., 2011). Especially in Nordic countries such as Finland, people are not used to high temperatures, and sick and elderly people are highly vulnerable to heat waves (Hassi and Rytkönen, 2005) (see Chapter 10, Urban Health). Therefore, more frequent periods of heat will increase demand for cooling. District cooling is a prominent example where Ad-Mit synergy can be found: air-conditioning systems with high emissions can be replaced by district cooling using energy that would be otherwise wasted (Riipinen, 2013). The district heating and cooling system (DHCS) of the energy company Helen Oy in Helsinki represents state-of-the-art technology that contributes to both climate change mitigation and adaptation (see Figure 4.2). It has increased the energy efficiency of buildings significantly, improving air quality in Helsinki and simultaneously providing an energy-efficient adaptation tool to avoid conventional air-conditioning in summer time. District heating and cooling can also be a major resilience

Table 4.3 *Interrelationships between adaptation and mitigation: Examples of sectors and practice measures in selected cities*

Sectors and measures	Interrelationship type	Examples of benefits	Examples of challenges	Climate policy	City	Country	Case study number
Urban forestry: Reforestation	Synergy	Carbon sequestration, flood protection, biodiversity	Space requirements	Adaptation	Durban	South Africa	4.1
Water: Open storm water systems via urban wetlands	Synergy	Flood protection, carbon sequestration, biodiversity, recreation	Space requirements	Adaptation	Colombo	Sri Lanka	4.2
Urban structure and design: Compact urban design	Conflict/tradeoff	Less carbon emissions	Restriction of green structures to mitigate heat island effect	Mitigation	Jena	Germany	4.3
Implementation of measures across multiple sectors	Synergy	High level of stakeholder engagement: residents, businesses, and community representatives	Fiscal and jurisdictional challenges	Adaptation/ Mitigation	Chula Vista, California	United States	4.4
Implementation of measures across multiple sectors	Diverse types	Integrated climate action planning	Monitoring and evaluation in an integrated manner	Adaptation/ Mitigation	Quito	Ecuador	4.5
Implementation of measures across multiple sectors	Diverse types	Integrated climate action planning	Implementation responsibilities, economic feasibility of actions	Adaptation/ Mitigation	Mexico City	Mexico	4.6

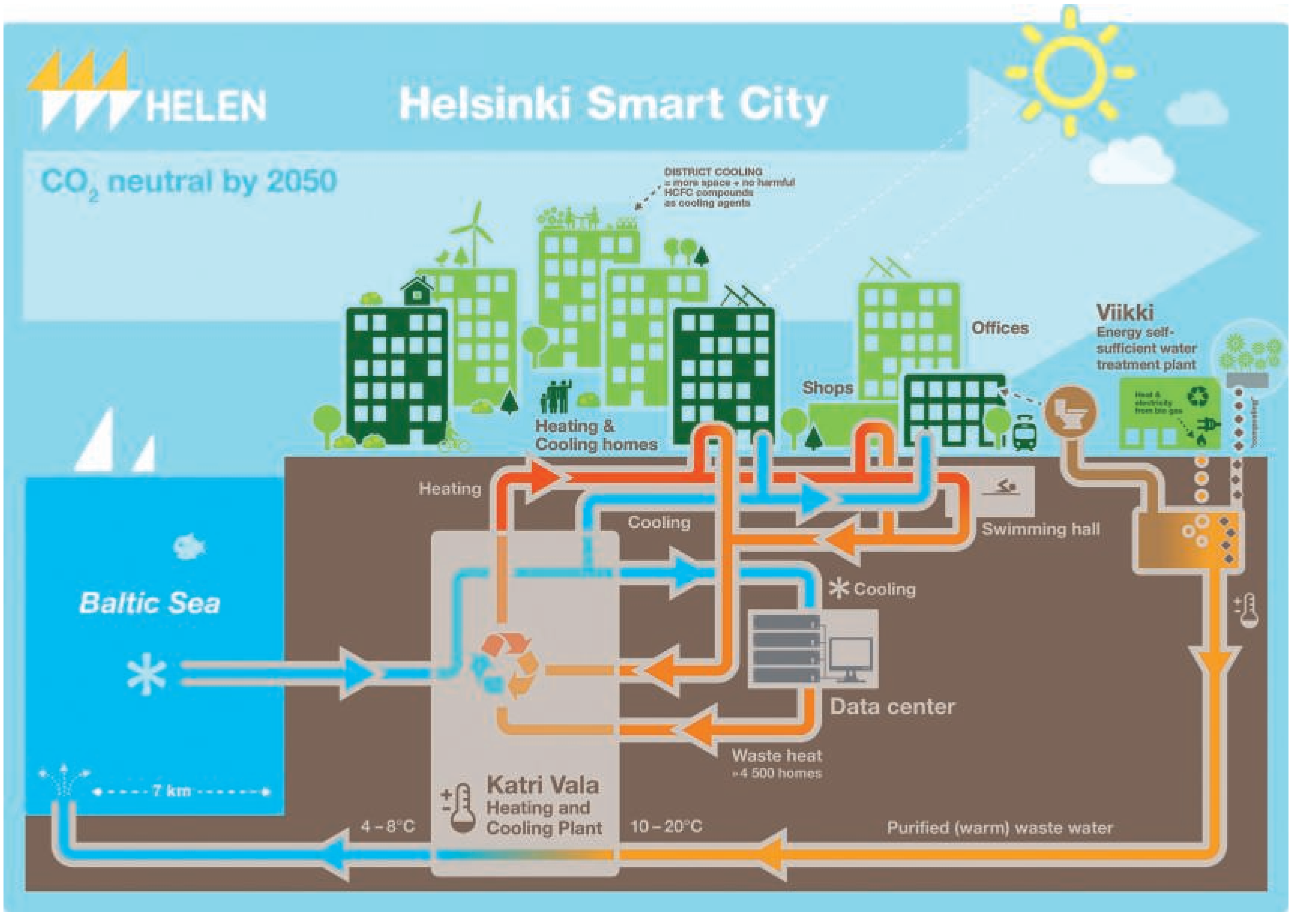


Figure 4.2 *Illustration of the district heating and cooling system in Helsinki.*

Source: Helen Oy; copyright Kirmo Kivelä

investment by reducing the risk and impact of power outages. Although the DHC system in Helsinki is still partially based on fossil fuels, energy savings by using combined heat and power production is equivalent to the consumption of 500,000 detached homes with conventional systems (Riipinen, 2013).

Synergies between adaptation and mitigation in the energy sector can also be found in decentralized renewable generation connected through smart grids (see Chapter 12, Urban Energy). Such options reduce GHG emissions and, at the same time, reduce risks of power shortages due to peak loads or supply disruptions under temperature extremes or storm-related power losses (Hamin and Gurran, 2009; Grafakos and Flamos, 2015). Furthermore, smart grids allow a large number of distributed energy generators to feed into the grid and thus improve system reliability in response to impacts of climate change on individual elements of energy production, transfer, and distribution. Small hydropower plants are based on renewable sources (hence mitigating GHG emissions) but require adequate design and operation in areas where scarce water supplies can reduce the adaptive capacity of ecosystems (Sugar et al., 2013). In the case of technical measures for adaptation such as water pumping and desalination, an option to minimize the conflict between mitigation and adaptation is to use renewable energy sources such as photovoltaic or wind power generating systems.

Urban greening is also a synergistic mitigation-adaptation measure (see Chapter 14, Urban Water Systems, and Chapter 8, Urban Ecosystems). The main benefits of urban greening are the capacity to absorb and store water, cool surrounding areas, improve biodiversity, and sequester carbon through wider subregional regeneration (Kithiia and Lyth, 2011; Newman, 2010; Piper and Wilson, 2009; Rankovic et al., 2012). An example of reforestation for carbon storage is presented from Durban, South Africa (see Case Study 4.1).

In Sri Lanka, a plan for recovering wetlands with replanted native trees aims to provide multiple benefits to the environment such as protecting biodiversity, providing flood protection for buildings and road infrastructure, increasing security of the population, and increasing carbon sequestration capacity (see Case Study 4.2).

Green roofs, roof gardens, and green walls for buildings help to mitigate climate change by providing carbon sinks, reducing albedo, regulating indoor temperatures while consuming less energy, improving water management, enhancing local biodiversity and landscapes, and even making urban agriculture possible (Williams et al., 2010; Lehman, 2015; Prochazka et al., 2015). These options, however, require adequate support and proper maintenance to avoid leakages and mold and to secure water

Case Study 4.1 Synergies, Conflicts, and Tradeoffs between Mitigation and Adaptation in Durban, South Africa

Sean O'Donoghue and Debra Roberts

eThekwini Municipality, Durban

Keywords	Renewable electricity, feed-in tariff, reverse auction, mitigation
Population (Metropolitan Region)	3,000,000 (eThekwini Municipality, 2015)
Area (Metropolitan Region)	2,297 km^2 (eThekwini Municipality, 2015)
Income per capita	US$12,860 (World Bank, 2017)
Climate zone	Cfa – Temperate, without dry season, hot summer (Peel et al., 2007)

DURBAN CASE STUDY

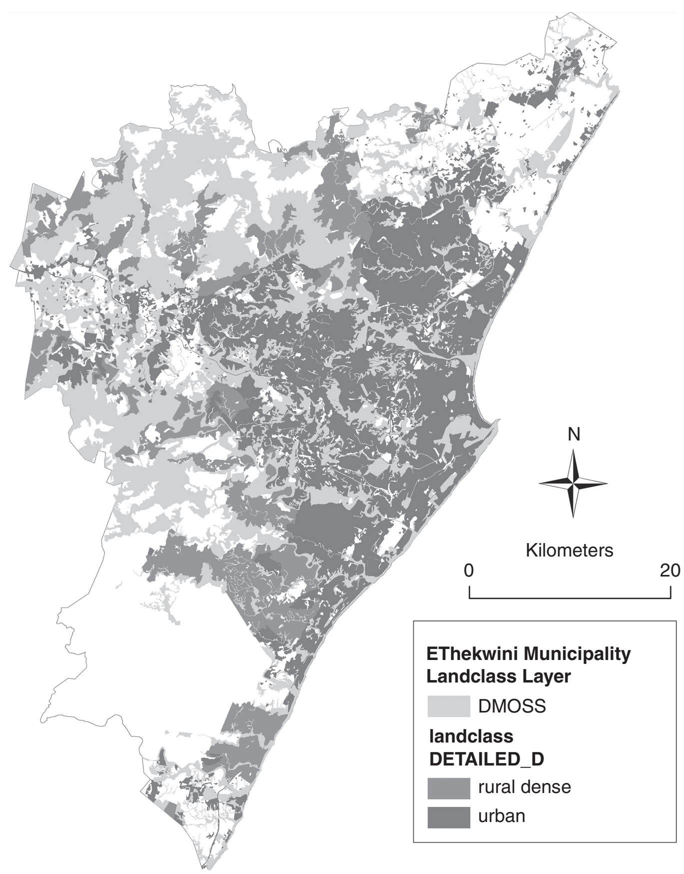
In the case of Durban, the synergies, conflicts, and tradeoffs between mitigation and adaptation action need to be understood within the context of a large, local development deficit. Durban has high levels of unemployment and poverty, high crime rates, substantial infrastructural backlogs, and high rates of HIV infection. These immediate needs compete with an issue like climate change for political attention and resources, so any climate protection action must have development co-benefits.

The city authority responsible for Durban is eThekwini Municipality. Unusually, this Municipality has prioritized adaptation in responding to the climate change challenge. This approach is supportive of the broader African agenda as relates to climate change. Hosting the United Nations Framework Convention on Climate Change (UNFCCC)'s 17th Conference of the Parties (COP17) negotiations in 2011 gave Durban an opportunity to advocate for climate change adaptation action at the city level, raise climate change awareness within both the Municipality and South Africa, develop partnerships and networks, and catalyze the implementation of adaptation and mitigation projects as part of the event greening program. This program aimed to reduce the ecological impact associated with hosting COP17. Core focus areas included carbon neutrality, resource and energy efficiency, ecological footprinting, and the production of an event greening set of guidelines with an awareness campaign focused on responsible accommodation and tourism.

EThekwini Municipality put out a public call for potential carbon offset options for COP17, but, of the five submissions received, none was regarded as suitable. The evaluation process used the UN Development Programme's Millennium Development Goals Carbon Safeguard Principles to assess the environmental and social sustainability of the proposed offset projects and the sustainability track record of the organizations involved. The negative outcome highlighted that carbon offsetting potential and sustainability are not necessarily synonymous and that the full range of benefits and disadvantages of any offset option must be carefully reviewed.

In the absence of suitable externally sourced offset options, the Municipality expanded the carbon sequestration work undertaken for the Durban 2010 FIFA™ World Cup through the initiation of a community-based reforestation project located adjacent to a local nature reserve. Over and above carbon sequestration, the project also helps improve the ecological health of the nearby river catchment, an important watershed with high levels of urban development and many poor communities, all of whom rely to some extent on the ecosystem services delivered within the catchment. Project implementation has occurred in partnership with local communities, nongovernmental organizations, the private sector, and provincial government and has employed 118 residents in tree planting (615,845 trees planted in 489 ha), invasive alien plant clearing (1.185 ha), ecosystem restoration, and fire protection, and as community facilitators supporting 495 "Treepreneurs" (i.e., indigent community members who source locally indigenous seeds and grow them into seedlings that are traded for critically needed supplies such as food, clothing, and building materials).

The project is also significant in that it resulted in the development of the Community-Ecosystem-Based Adaptation (CEBA) concept. This looks to eventually expand the original reforestation approach to embrace a more complete understanding of the link between communities and the ecosystems that underwrite their welfare and livelihoods by creating cleaner and greener neighborhoods that are less dependent on costly utilities and services (e.g., through water recycling and the use of renewable energy). The CEBA approach is now being implemented throughout the province of KwaZulu-Natal. There is a clear synergy among adaptation, mitigation, and the development needs of Durban's residents, and this is being used



Case Study 4.1 Figure 1 *EThekwini Municipality (29°51´31˝S; 31°01´19˝E) with urban/peri-urban areas and the Durban Metropolitan Open Space System (DMOSS).*

Source: Roberts and O'Donoghue, 2013

to define a new development paradigm, where natural infrastructure is used to generate multiple developmental benefits for local residents.

In Africa, the current rapid rate of urbanization means that there is an urgent need to ensure that an appropriate and integrated adaptation and mitigation framework is put in place to ensure that African cities take advantage of the opportunity to leapfrog the carbon-intensive and ecologically destructive development path of the past and that this framework engages in an appropriate way with the challenge of high levels of informality and still-evolving governance structures. This requires that the climate question is asked in a different way in Africa – that is, how does a low carbon development pathway create increased adaptive capacity, and how can that adaptive capacity be used to meet growing development needs in a more sustainable and resilient way? To enable this, innovative finance mechanisms that directly support city-level action are essential following COP21 in Paris, 2015.

Case Study 4.2 Pilot Application of Sustainability Benefits Assessment Methodology in Colombo Metropolitan Area, Sri Lanka

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Monali Ranade and Sarah Mills-Knap

The World Bank Group, Washington, D.C.

Keywords	Integrated assessment, sustainability benefits, adaptation–mitigation interrelationships, ecosystem based adaptation, floods
Population (Metropolitan Region)	2,195,000 (Demographia, 2016)
Area (Metropolitan Region)	3,684 km^2 (SLRCS, 2015)
Income per capita	US$11,970 (World Bank, 2017)
Climate zone	Af – Tropical, rainforest (Peel et al., 2007)

This case presents the green growth project Bedaggana Wetland Development in Colombo Metropolitan Area, Sri Lanka, and the pilot application of an integrated Sustainability Benefits Assessment (SBA) methodology developed by the Institute for Housing and Urban Development Studies (IHS) in cooperation with the World Bank for capturing and quantifying its sustainability benefits including those related to climate change mitigation and adaptation.

This project is part of the integrated improvement, management and maintenance of flood-detention areas around Parliament Lake, funded by The World Bank 2017. Part of the wetland will be replanted with native tree species. This will enhance the natural environment in the area and protect the rich biodiversity of the wetland, increase the flood-retention capacity, and facilitate climate change mitigation through carbon sequestration.

The SBA methodology is a combination of top-down and bottom-up approaches including geographical information system (GIS)-based scenario building (Fraser et al., 2006; Graymore et al., 2009). This helps in the process of identifying specific sustainability benefits of different types (i.e., social, environmental, and economic) including mitigation and adaptation benefits that can be accrued at different levels (i.e., individual, local community, and global community) from various green growth projects. The methodology creates map-based scenarios that enable better identification and overall visualization of sustainability benefits. The *ex-ante* methodology consists of five steps, which are explained below as they apply to the Bedaggana Wetland Development project (see Case Study 4.2 Figure 1).

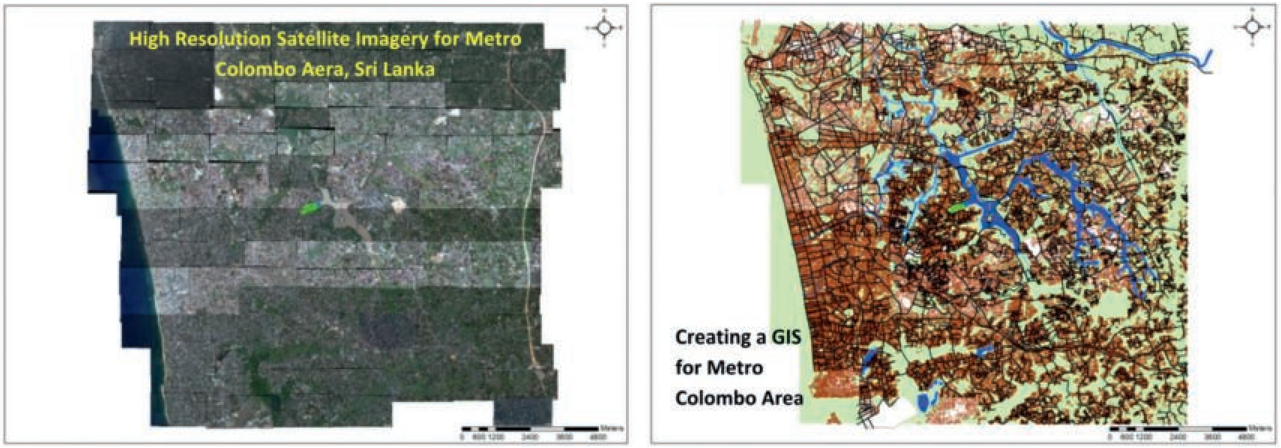
STEP 1: CREATE AN EXISTING SITUATION SCENARIO (BASELINE)

The first step of the SBA consists of creating the existing situation scenario (or baseline) that provides information on the current state of sustainability of the project area. A GIS is used to create and manage a multidimensional, multipurpose, and multitemporal database in a common frame of reference. A geospatial database was created for the entire Metro Colombo Area (see Case Study 4.2 Figure 2).

Case Study 4.2 Figure 1 *Location of Bedagana Wetland Development Project*

STEP 2: DEVELOP A "WITH-PROJECT" SCENARIO

The scenario "With-project" characterizes the incremental net changes brought about by the implementation of the project. It is based on a GIS map and provides a summary of the project's main objectives, activities, and expected outcomes in different sustainability benefit categories (see Case Study 4.2 Figure 3).



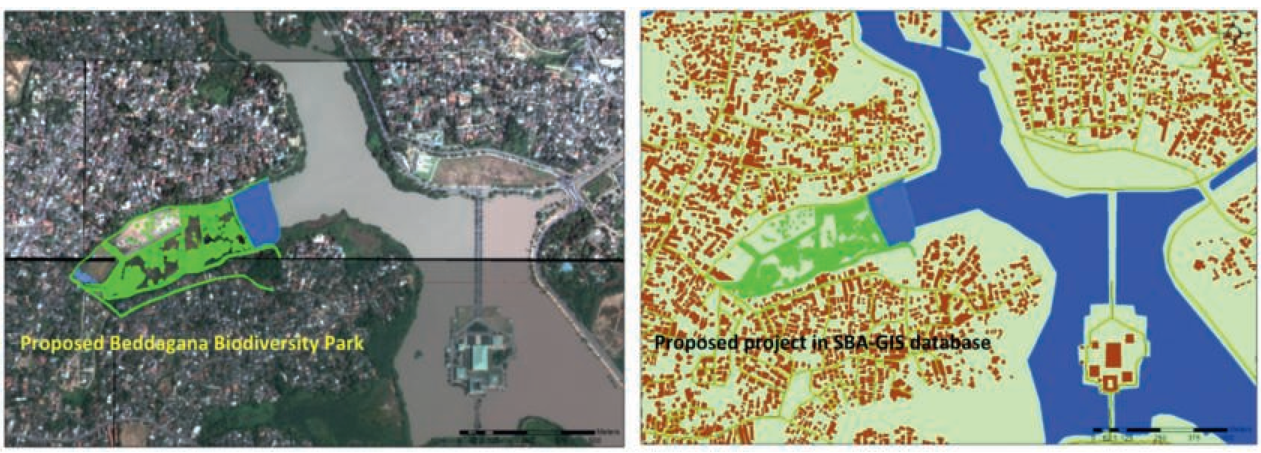
Case Study 4.2 Figure 2 *Geographical Information System (GIS) for Metro Colombo Area*

STEP 3: IDENTIFY OF PRIMARY PHYSICAL IMPACTS

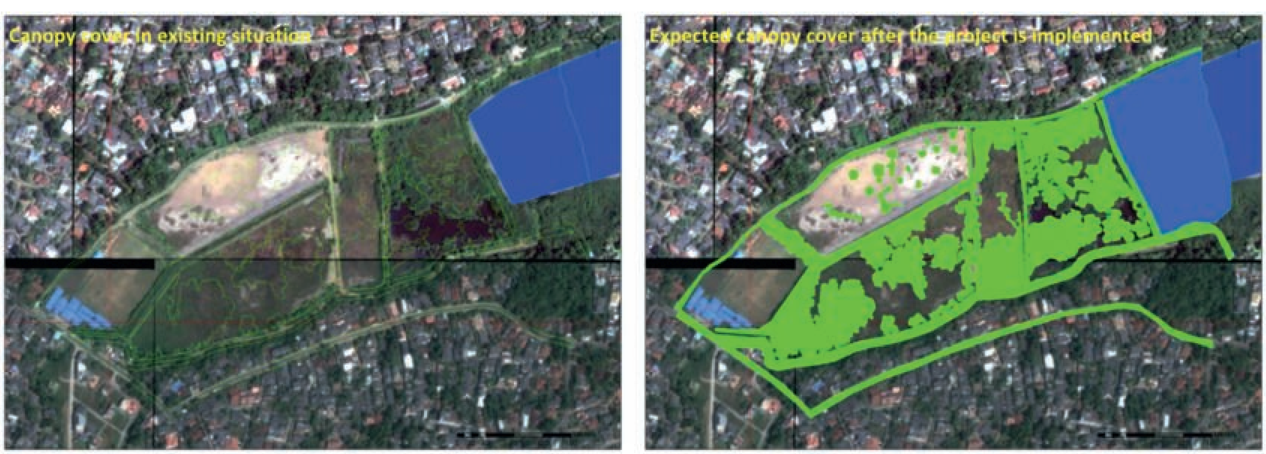
At this stage, various expected sustainability benefits are associated with the actual physical changes (primary impacts) that the project will bring after implementation. The project scenario is compared with the existing situation scenario in terms of physical characteristics. In the case of the Bedaggana Biodiversity Park project, the analysis suggested that the development of the area will mainly bring the following three primary physical changes in the baseline:

- Increase of wetland area
- Increase in canopy cover
- Development of recreational area

As an illustration of one of the primary impacts, the map shows the development of a "pocket" of urban forest in the Biodiversity Park. The three changes in the baseline will lead to several sustainability benefits (see Case Study 4.2 Figure 4).



Case Study 4.2 Figure 3 *Mapping the Project Scenario*



Case Study 4.2 Figure 4 *Canopy cover in the Beddagana Biodiversity Park area*

STEP 4: MEASURE THE SUSTAINABILITY BENEFITS FOR MITIGATION AND ADAPTATION

At this stage, the benefits are categorized by type (social, environmental, economic) and level (individual, local community, global community) of benefit. The sustainability benefits expected from the Beddagana Biodiversity Park development project are:

- *Adaptation benefits* associated with increase in flood retention capacity. In order to analyze the effect of flood risk reduction in the area around Beddagana Biodiversity Park, a hydrological analysis for the area was carried out. When the building footprints and road infrastructure layers are overlaid, it can be estimated how many built assets and how much road length can benefit from flood prevention due to the implementation of the project.
- *Mitigation benefits* associated with increase in canopy cover. It was assumed that about 95 tons of carbon would be stored per hectare of tree cover in the Bedaggana Biodiversity Park. In the existing situation scenario, total tree cover in the Beddagana wetland site is about 3 hectares, which will increase to 11 hectares after the trees are fully grown if planted according to the proposed design of the park. This will increase carbon storage capacity of the site from 285 tons per annum to around 1,045 tons per annum.

STEP 5: DOCUMENT ADAPTATION-MITIGATION BENEFITS IN THE SUSTAINABILITY BENEFITS MATRIX

Final step of the SBA methodology is to document all the sustainability benefits into a two-dimensional matrix, the Sustainability Benefits Matrix. The sustainability benefits are classified according to their level and type. Social benefits associated with the development of a recreational are also measured.

requirements (Laukkonen et al., 2009; Thornbush et al., 2013; Hodo-Abalo et al., 2012). Various attempts to quantify the costs and multiple (including adaptation and mitigation) benefits of green roofs have been made (see, e.g., Blackhurst et al., 2010; Bianchini and Hewage, 2012). There are also urban governments (e.g., Chicago, Montréal, and Portland, Oregon) that have commissioned or conducted studies to quantify the benefits of green roofs in their cities (City of Portland, 2008; City of Chicago, 2011; Gariepy, 2015). The Chicago Green Roof Initiative in 2011 resulted in about 5,470,000 square feet of green roofs that reduce the output of approximately 21 metric tons of carbon each year and absorb approximately 124 million gallons of storm water per year.

Tradeoffs between adaptation and mitigation often appear in situations where decisions have to be made on “hard” versus “soft” engineering and planning solutions, as well as in situations where the temporal scale of implementation sets limitations or uncertainties regarding planning horizons, availability of resources such as financing and staff, overall limits of authority, availability of expertise and data, and availability of physical space to implement integrated solutions (Jordan, 2009; Juhola et al., 2013; Dymén and Langlais, 2013).

Conflicts between adaptation and mitigation are often spatial in nature given that many of the adaptation measures (such as water management practices using urban forestry and urban greening) require significant land area in order to be effective. Poorly planned, such efforts may undermine urban densification efforts that are key to reducing transportation and energy demands (Dymén and Langlais, 2013; Viguié and Hallegatte, 2012; Hamin and Gurran, 2009). Expanding urban green space can increase emissions from transportation due to longer commuting needs – an example of adaptation that negatively affects mitigation.

Furthermore, some water sector adaptation measures potentially conflict with mitigation measures because they have high energy demand – such as desalination to tackle water scarcity and water pumping to reduce flooding (Cooley et al., 2012; Cook et al., 2012) (see Chapter 14, Urban Water Systems). Sometimes these measures can be implemented at the micro-scale level, with marginal effects on mitigation. In some cases, the conflict can be minimized or eliminated by supplying renewable energy (e.g., based on photovoltaics) to meet the energy needs of water treatment and supply, as was the case in Amman, Jordan (Al-Karaghouli et al., 2011; Sugar et al., 2013). However, cases like the Chinese interbasin transfer project present significant energy requirements, as well as posing considerable risks of water shortages upstream (see Box 4.3).

The Chinese central government aims, through the Special Plan for Seawater Utilization, to produce 3 million tons (807 million gallons) of purified seawater a day by 2020, approximately four times the country’s current capacity. At least 400 of the largest Chinese cities already suffer from water scarcity. According to Cooley et al. (2012), 12,000–18,000 kilowatt hours will be needed to desalinate a million gallons of seawater, whereas pumping groundwater to the surface requires less than 4,000 kilowatt hours per million gallons.

Additional examples of *mitigation-adaptation interrelationships* can be found in urban design and densification policies (see Chapter 5, Urban Planning and Design). On the one hand, urban densification maximizes agglomeration economies through more efficient resource use, waste management reduction, reductions in urban sprawl, and a lower reliance on motorized transport (Hickman et al., 2013). On the other hand, increased urban density may affect food belts, riparian areas, and wetlands that protect cities from floods. It can increase heat islands, for instance, by blocking free air flow, which may lead to pollution, discomfort, and health problems and to an increased need for conventional cooling (Hamin and Gurran, 2009; Laukkonen et al., 2009) (see Chapter 2, Urban Climate Science). Air conditioning that uses conventional fossil fuel electricity to provide cooling services conflicts with mitigation efforts (Dymén and Langlais, 2013; Sugar et al., 2013).

Furthermore, urban planning practices that support urban densification often result in the loss of permeable surfaces and tree cover, increased risk of flooding, and water pollution (Mees and Driessen, 2011). Densification of urban areas tends to reduce natural drainage possibilities, thereby making it more expensive and difficult to implement adaptation measures. Diminishing natural urban

Box 4.3 China's Eastern Route Project: A Challenge for South–North Water Diversion

China's Eastern Route Project (ERP) is a project aimed at supplying water to the northeastern part of the country by fossil-fuel based pumpings; Wang et al., 2006). A third of Beijing's annual demand is to be supplied by a new watercourse pumping from the Danjiangkou Dam in the central province of Hubei to the capital. The more than US$62 billion ERP is part of a larger water diversion project: the second phase of which is known as the South-North Water Diversion Project. It is designed to supply the dry, urbanized, and farming-intensive north of China. Initially conceived in 1952, the ERP was commissioned in 1972 after a prolonged drought in Northern China; the first phase was commissioned in 2002. According to official sources, the 1,156-kilometer ERP will divert to the north 14.8 billion cubic meters of water from the Changjiang River flow of more than 600 billion cubic meters per year. In the first of thirteen engineering stages, fifty-one pumping stations with an installed capacity of 529 megawatts will be built. Waste water plants will also be built (Chinese Government, 2012).

drainage possibilities also affect the safety and security of urban dwellers if floods occur, especially if vulnerable urban dwellers cannot be relocated to flood-secure areas (cf. Sugar et al., 2013). Health impacts can also be expected if urban recreational possibilities are reduced (van Dillen et al., 2012). Biodiversity losses in urban areas can also result due to smaller and fewer green (and blue) spaces (Fontana et al., 2011). The use of biofuels by urban dwellers may have positive effects for mitigation due to decreased use of fossil fuels and consequently reduced carbon emissions, but this creates potential conflicts with broader-scale adaptation because biofuels production requires land; this competes with agricultural use and therefore affects food security (Smith et al., 2014).

Some of the conflicts stemming from adaptation measures (such as urban greening that requires considerable space) can be diminished and synergies enhanced by using multimodal and public transportation, hybrid vehicles and other cleaner technologies, and planned transportation routes along green and blue areas (Saavedra and Budd, 2009; Hamin and Gurran, 2009). Adaptation measures can enhance mitigation when population resettlement is connected to the restoration of degraded areas. The São Paulo Case Study shows how adaptation measures (relocation and protection from flooding in landslide-prone areas) were combined with mitigation strategies (recovery of forests, storage of carbon in vegetation and soils) to address existing conflicts created by uncontrolled urbanization (see Case Study 4.B in Annex 5). Jakarta provides a similar successful example of slum upgrading and relocation of a vulnerable community to safe areas with energy-efficient homes connected to public transit and community-based electricity generation (Sugar et al., 2013).

Finally, there are interesting examples of integrated Mit-Ad/Ad-Mit strategies from middle-sized cities in Europe and the United States (see Case Studies 4.3 and 4.4).

Case Study 4.3 Jena, Germany Adaptation Strategy as an Essential Supplement to Climate Change Mitigation Efforts

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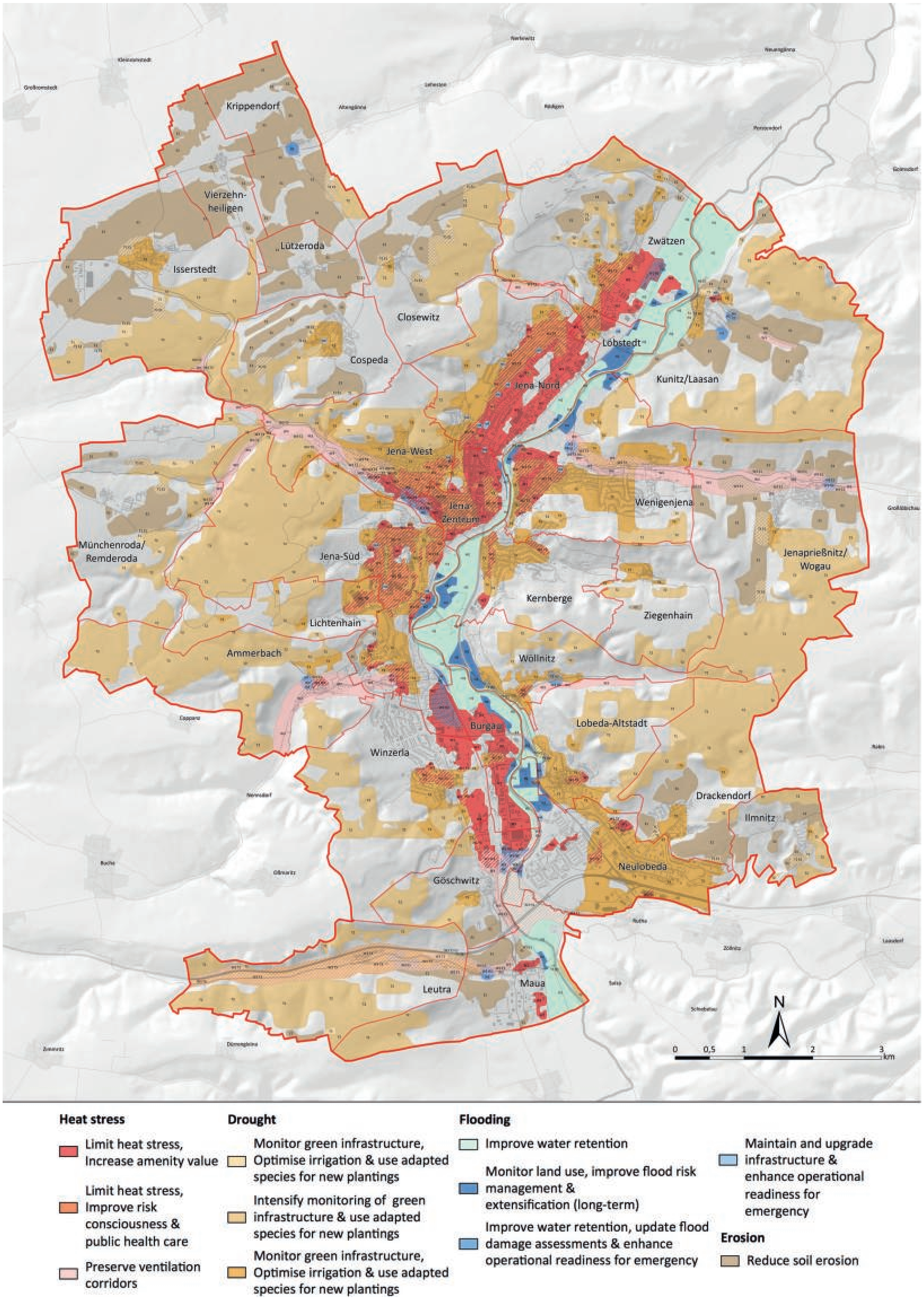
Keywords	Adaptation, mitigation, climate-proof urban planning, decision support, multicriteria analysis, heat stress, flood
Population (Metropolitan Region)	457,578 (Statistical Office State of Thuringia, 2015a)
Area (Metropolitan Region)	1,271 km² (Statistical Office State of Thuringia, 2015b)
Income per capita	US$49,530 (World Bank, 2017)
Climate zone	Cfb – Temperate, without dry season, warm summer (Peel et al., 2007)

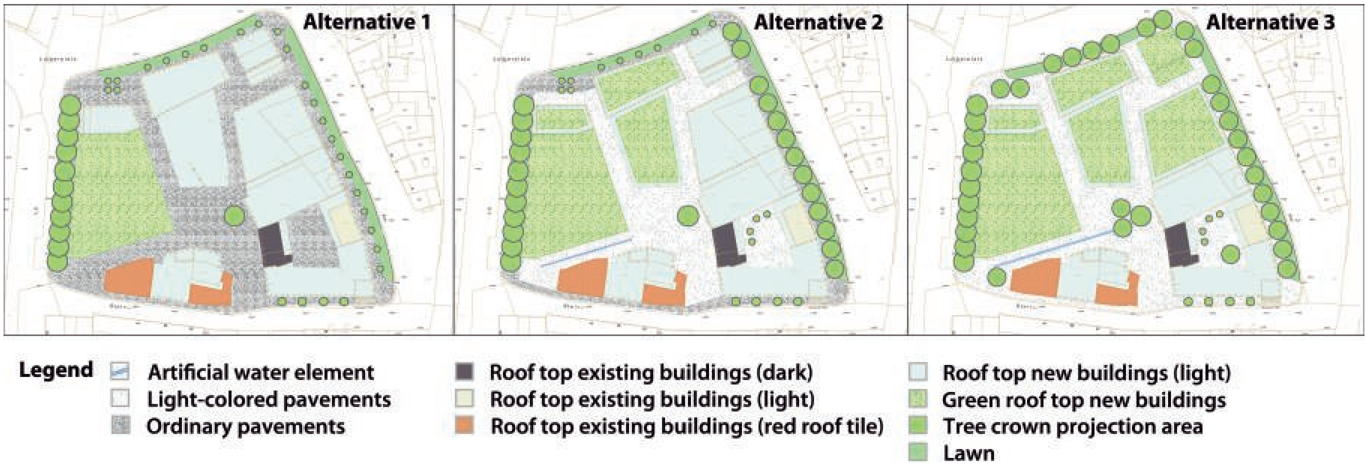
Jena is a prosperous city of about 100,000 inhabitants located 250 kilometers southwest of Berlin, Germany in the hilly landscape of the Saale River valley. Since the late 19th century, owing to the activities of the entrepreneur Carl Zeiss, the city has become the center of the optical industry, which is known worldwide. The strong urban economy and large science and technology sector form the basis of the population's high standard of living. Due to its specific location, the city is exposed to various climate-related threats, especially heat stress, fluvial floods and pluvial downpours.

The city center is surrounded by steep shell limestone slopes, which operate as a thermal storage system, making Jena one of the warmest places in Central Germany. Based on current climate projections, an increase of heat stress events is expected. By the end of the century, the average maximum temperature in the summer will increase by 3°C (CMIP5, RCP 4.5) to 6°C (CMIP5, RCP 8.5). Accordingly, the number of hot days, i.e., days with a maximum temperature of at least 30°C, will rise from 11 in 1981–2010 to 35 (CMIP5, RCP 4.5), or 49°C (CMIP5, RCP 8.5).

Numerous tributaries flow from the surrounding plateau and discharge in the floodplain of the Saale River, which crosses the city



Case Study 4.3 Figure 1 *Recommendations for urban planning in particularly affected areas in Jena, Germany.*



Case Study 4.3 Figure 2 *Alternative project designs of an urban square in Jena used as a basis for an adaptation check.*

center and industrial areas. Heavy or long-lasting precipitation events repeatedly cause major floods. Experience from the recent past and modeling results from other German river basins suggest an increase of peak discharges especially for flood events occurring with a medium-to-high probability.

Given this situation, in 2005, urban planners and scientists started discussing how these risks might change over time and how related impacts could be managed. In 2009, the Department of Urban Development & City Planning (DUDCP) commissioned and financed a pilot study to analyze local climate change impacts, identify potential adaptation measures, and better understand the risk perceptions of relevant stakeholder groups. On the basis of the results of this study the decision was taken to develop a local climate change adaptation strategy *Jenaer KlimaAnpassungsStrategie (JenKAS)*. The development was initiated as well as steered by DUDCP and financially supported by the federal government of Germany. It involved experts from all relevant departments of the city administration and agencies of the federal state of Thuringia, interested stakeholder groups (e.g., associations and cooperatives), scientists, and politicians.

JenKAS was formally adopted by the City Council in May 2013 and consists of various elements. Its backbone is a handbook on climate-sensitive urban planning (City of Jena 2013), which includes information on current and future climatic conditions and their potential local impacts, information on legal aspects of climate change adaptation, economic assessments of adaptation options, and best practice examples of successful climate change adaptation in Jena and elsewhere. For each city district, impacts are described in detail, and related risks are visualized using a traffic-light labeling system. Recommendations for urban planning in particularly affected areas are presented (see Case Study 4.3 Figure 1).

The handbook is complemented by the decision support system *Jenaer Entscheidungsunterstützung für lokale Klimawandelanpassung (JELKA)*. This tool was developed to make climate risk information more accessible and to provide tailor-made recommendations for different target groups (e.g., suitable adaptation measures for a specific field of action or spatial unit).

In Jena, adaptation is understood not as a substitute but as an essential supplement to climate change mitigation efforts. Since the turn of the century, mitigation has been on the municipal political agenda as an important aspect of the city's sustainability goals. In 2004, the advisory board of the Local Agenda 21 started to develop an urban climate change mitigation concept, which was officially approved in 2007. The implementation of the concept is monitored, revised, and extended on a regular basis. The increasing demand for reducing carbon emissions triggered the development of an integrated mitigation strategy, which was completed and approved in 2015. On the basis of the manifold activities stimulated by the mitigation agenda, Jena was the first German city to be awarded the European Energy Award Gold. Until 2014, only two other German municipalities received this prestigious award. The achievements of the past years include such diverse activities as the use of 100% renewable energy in all public buildings, the development of a new urban cycling and public transport concept, numerous energy-saving activities, the introduction of car-sharing incentives, and the establishment of a façade greening award. The city's biannual energy action plan comprised more than fifty measures for the years 2014 and 2015.

Because there are not only synergies but also potential conflicts between adaptation and mitigation measures, special interest has been paid to take these contradictory effects into consideration when developing recommendations for improving climate resilience. Urban planners in Jena are guided by the urban design concept of the compact city. On the one hand, limiting outward urban expansion and promoting dense urban structures by efficiently using land resources improves energy efficiency, but, conversely, this density is likely to restrict the establishment of green structures to mitigate urban heat island effects. In Jena, this potential conflict was balanced by recommending that planners should retain the compact city as a guiding principle but also to preserve areas to allow ventilation of fresh and cold air to the inner-city residential and commercial areas. A map representing intranight airflows was made available to planners to inform them about these corridors.

The main focus for the implementation of JenKAS is on mainstreaming climate change adaptation into administrative decision-making. DUDCP promotes the consideration of adaptation-related aspects in these processes through various in-house activities, such as JELKA trainings. As a consequence of these efforts, a constantly growing number of land development plans refer to JenKAS when making recommendations or substantiating restrictions. It is expected that the results of ongoing and future research efforts (e.g., a highly awarded urban tree concept providing site-specific tree recommendations based on climatic, locational, aesthetic, and even historico-cultural considerations) will further promote this uptake. Beyond the actions directed at internal municipal processes, there are several activities addressing citizens and associations (e.g., a nature trail with display boards financed by local businesses that provide information about important aspects of the changing urban climate as well as the city adaptation strategy).

One way of considering climate change in today's urban decision-making is to use adaptation checks when drafting plans for major (re)construction projects (see Case Study 4.3 Figure 2). Assisted by scientists from the Helmholtz Centre for Environmental Research – UFZ, probabilistic multicriteria analyses were conducted to facilitate the development of climate-proof detailed designs. It was intended that these drafts should not only suit current and future climate conditions but also take into account the manifold other factors (e.g., financial and aesthetic aspects) as well as stakeholder preferences affecting decision-making in urban planning. The results of these adaptation check rankings of the alternatives were calculated and rated their suitability from an adaptation perspective.

Due to the short period of time since the adoption of JenKAS, no systematic evaluation of its impacts has yet taken place, yet. However, several findings and recommendations for promoting urban climate change adaptation in Jena can still be presented:

- Potential conflicts of adaptation and mitigation efforts can be solved or at least limited by explicitly addressing these issues at an early stage of strategy and project development.
- Exchange between representatives of different administrative bodies, scientists, and consultants about adaptation activities at the various political scales and scientific progress in the field should be institutionalized and take place on a regular basis.
- Adaptation-related outreach activities of municipalities do not only raise awareness of the general public, but also improve civic and political support for adaptation action.
- Momentum created by the initial adoption of a local adaptation strategy should be maintained through projects that continuously update and expand the existing adaptation knowledge base.
- Trainings and hands-on workshops are essential to improve municipal staff's ability to use data and tools available for supporting adaptation.
- Public commitment of political decision-makers to support adaptation activities (e.g., the adoption of a local adaptation strategy by the city council) is pivotal for their success.

Case Study 4.4 Sustainable Win-Win: Decreasing Emissions and Vulnerabilities in Chula Vista, California

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Keywords	Mitigation, adaptation, integrated plan
Population (Metropolitan Region)	265,757 (U.S. Census,2015)
Area (Metropolitan Region)	128 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)

The coastal city of Chula Vista (in Southern California, U.S., 32°37´40˝N 117°2´53˝W), although small (128 km^2, pop. 243,916 in 2010), is a global benchmark in terms of planning and implementing integrated climate change mitigation and adaptation strategies (United States Census, 2015). The impact of Chula Vista´s climate policy is due to its replicability, resource efficiency, and focus. The relevance of Chula Vista resides in its comprehensiveness and level of implementation, driven by the vulnerabilities found in the Southern California Region, the level of awareness of the local community – a diverse population on a varied landscape, and a long history of progressive thinking on climate change (City of Chula Vista, 2011).

A Working Group comprising residents, businesses, and community representatives recommended eleven strategies to curb greenhouse gas (GHG) emissions and to adapt the community to key impacts within different sectors: energy and water supply, public health, wildfires, ecosystem management, coastal infrastructure, and the local economy (City of Chula Vista, 2011).

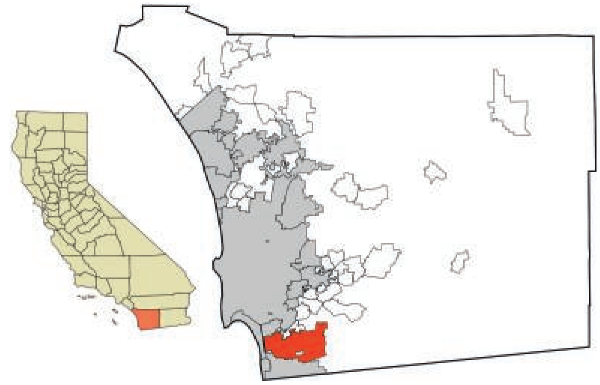
In the 1990s, the city formed the Climate Change Working Group and created a baseline inventory of its GHG emissions. From this starting point, mitigation strategies covering transportation (such as a 100% clean fuel bus fleet), energy efficiency and solar retrofits (an appliance rebate program), and green buildings with smart growth strategies (a city-wide standard) were devised (Green, 2010).

The Working Group researched the best available data and engaged the community in the consensus-based decision-making process. A list of eleven strategies comprised mitigation-adaptation (Mit-Ad) and adaptation-mitigation (Ad-Mit) measures including (1) cool paving, (2) shade trees, (3) cool roofs, (4) local water supply and reuse, (5) storm water pollution prevention and reuse, (6) education and wildfires, (7) extreme heat plans, (8) open space management, (9) wetlands preservation, (10) sea level rise and land development codes, and (11) green economy (City of Chula Vista, 2011).

The process was conducted in three phases. The first was information gathering, including data collection via public forums. Twelve meetings featured presentations from Working Group members and regional experts on the different adaptation topics and discussed the current state of practices and predicted impacts to the San Diego region. Public notices were posted prior to meetings at various municipal locations. Additionally, more than sixty additional stakeholder groups and community members were invited for feedback. A newsletter helped to build public awareness about the climate planning process. In an open public forum, more than thirty community members shared their opinions and priorities for strategies. The group came up with 183 options based on the best available data, summarized into a planning matrix for each focus area (Green, 2010; City of Chula Vista, 2011).

Step two was evaluation. after risk levels were assigned to each identified vulnerability in consultation with researchers from the

Case Study 4.4 Figure 1 *Chula Vista, California.*



Case Study 4.4 Figure 2 *Chula Vista, California.*

Case Study 4.4 Table 1 *Chula Vista's Implementation stage compared to other cities in the San Diego Region. Source: Center for Sustainable Energy, 2017*

Local Climate Planning Efforts (2000–2015)

Jurisdiction	GHG Inventory	Climate Action Plan (CAP)	
		Adopted	Developing or Updating
Carlsbad	x	2015	
Chula Vista	x	2000, 2008	x
Coronado	x		
County of San Diego (unincorporated)	x	2012	x
Del Mar	x	2016	x
El Cajon	x		
Encinitas	x	2011	x
Escondido	x	2013	
Imperial Beach	x		x
La Mesa	x		x
Lemon Grove	x		x
National City	x	2011	
Oceanside	x		x
Port of San Diego	x	2013	
Poway	x		
San Diego	x	2005, 2015	
San Diego County Water Authority	x	2015	
San Marcos	x	2013	
Santee	x		
Solana Beach	x		x
Vista	x	2012	

University of California San Diego. Risk was defined as a product of the likelihood of the climate change impact occurring and the consequence of the impact. Each factor was scored from 1 to 5, and overall risk was categorized as "Low," "Medium," or "High." The Working Group also consulted the Resource Conservation Commission, the Environmental Health Coalition, and the San Diego Coastkeeper (City of Chula Vista, 2011).

Finally, for each vulnerability, a priority was assigned according to criteria such as jurisdiction, fiscal feasibility, and complementarity. These criteria relate to (1) a strategy falling within the city's jurisdiction, (2) a strategy being fiscally feasible (not relying on General Fund support for implementation), and (3) a strategy not duplicating or contradicting current climate mitigation measures, hence building on existing municipal efforts rather than creating new stand-alone policies or programs. No-regret actions or actions having multiple co-benefits were regarded as high priority. Specific implementation components were outlined, as well as critical steps, costs, and timelines. Implementation of all strategies were projected to cost approximately US$554,000 over the course of three years, plus US$337,000 annually for ongoing activities (City of Chula Vista, 2011).

Lessons learned included engaging stakeholders, stressing preparedness instead of resilience, lowering risks, avoiding analysis paralysis, focusing on areas where the city could actually have influence, and integrating action plans and programs.

4.3.4 Opportunities and Challenges

Opportunities and challenges for integrating mitigation and adaptation measures arise at all stages of planning, from initial assessments to implementation, monitoring, and evaluation. The goal is decision-making for integrated climate change management in cities. A city's capacity to undertake integrated actions for climate change mitigation and adaptation is determined by structural conditions that can either provide the necessary opportunities or, on the contrary, impede and hinder integrated climate change action. Resources and technical means are at cities' disposal to overcome these barriers and better manage climate change challenges in an integrated manner.

4.3.4.1 Structural Conditions

Structural conditions define the current context and boundaries of a city's operating system. Structural conditions are comprised of the environmental and physical setting, institutions and governance, economic and financial conditions, and sociocultural characteristics of a city (see Figure 4.3a). Structural conditions are difficult to change in the short run and often require coherent, continuous, and persistent action in order to influence them. Structural conditions to a large extent determine the level of a city's vulnerability and GHG emissions, but also its capacity to adapt to climate change impacts and reduce GHG emissions.

Environmental and physical setting: This refers to the main physical limits (e.g., all types of land uses, availability of freshwater), local conditions (e.g., urban traffic patterns and distribution, buildings characteristics, land-use zoning, hotspots such as UHIs), and infrastructure systems (the long-term, fixed nature of infrastructure creates path dependencies, thus diminishing or enhancing a city's ability to adapt and reduce GHG emissions in the short term). For example, coastal cities are threatened by sea level rise and storm surges and therefore require investments for flood defense measures.

Institutions and governance setting: This entails existing policies and institutions including current plans, standards, and regulatory frameworks that could determine opportunities or constraints for integrated climate actions as well as interactions between different levels of jurisdictions. For example, urban areas may find it hard to adopt an integrated climate change action plan for the entire metropolitan region because of inter-jurisdictional conflicts or regulatory systems that contradict each other (UN-Habitat, 2015). Overlaps between different policy instruments and ineffective coordination of programs within and between municipal departments as well as among multiple levels of government (national, provincial, and municipal) can limit integrated approaches to climate change planning and management (Burch, 2010; Moser, 2012).

Economic development and municipal finances: These are also important structural conditions that determine a city's capacity to adapt and mitigate. Cities with advanced economic development and diversification can have high adaptive and mitigation capacity and thus the ability to develop and implement efficient low-carbon technologies that also increase climate resilience (Bizikova et al., 2008). Economic development and wealth enhance adaptation and mitigation capacity (Bergquist et al., 2012). The feasibility of implementing instruments for climate change mitigation is highly dependent on a city's financial and governance capability (Seto and Dhakal, 2014). In addition, long-term sustainable growth requires long-term budgetary equilibrium (Georgeson et al., 2016).

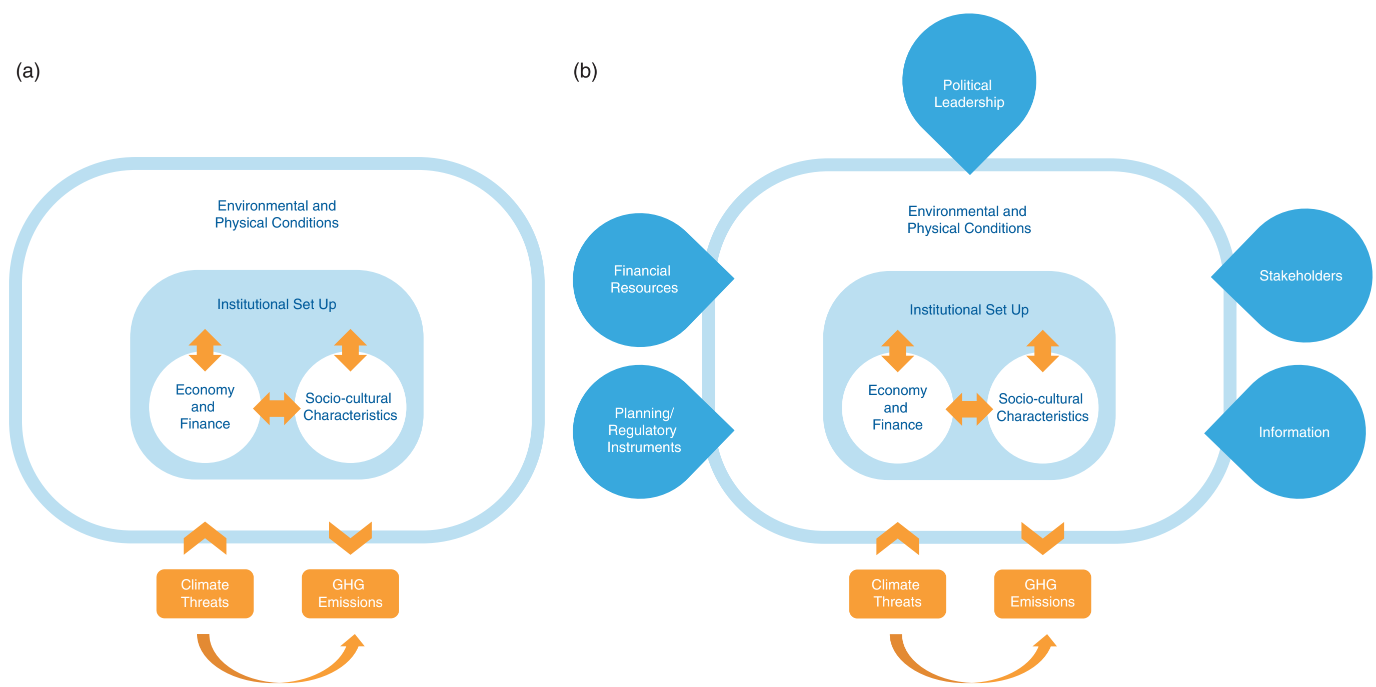


Figure 4.3a *Structural conditions that determine a city's capacity to adapt and mitigate.*

Figure 4.3b *Resources and technical means for cities to overcome barriers for integrated climate change response due to specific structural conditions.*

Sociocultural characteristics: These include cultural values and worldviews that play an important role in how climate-related risks are perceived among individuals and organizations, and how policies and practices to respond to climate impacts and risks could or should be implemented. They may influence the acceptance of low-carbon and risk-reduction solutions or lead to a misperception of impacts and their causes, consequently affecting preferences for responsibility and behavioral patterns (Shove, 2010; Greenham et al., 2012). There is also a challenge to change older perspectives that view mitigation and adaptation as conflicting alternatives rather than complementary ones, a view that often leads to the perception that the implementation of adaptation policies would imply abandonment of mitigation policies (Moser, 2012). Cultural values and worldviews may also affect perceptions of equity and justice (Creutzig et al., 2014) (see Chapter 6, Equity and Environmental Justice).

4.3.4.2 Resources and Technical Means

Certain resources and technical means can be used to overcome barriers to integrated responses that might exist or barriers that can appear due to deficits of specific structural conditions or other constraints (see Figure 4.3b). Key means and resources are stakeholder engagement and participation in the planning and decision-making process and information in all dimensions and forms (such as awareness-raising campaigns and education). In addition, financial resources and mechanisms at all stages of policy development, project initiation, and implementation, along with planning and regulatory instruments, are parts of the capacity needed in cities. Political leadership is a vital factor that can often drive climate policy and determine its successful implementation (Lesueur et al., 2015; Burch, 2010; Johnson and Breil, 2012) (see Chapter 16, Governance and Policy)

A wide range of urban actors (government, practitioners, public and private companies, the scientific community, and stakeholders from civil society such as boundary organizations) are needed for effective planning and implementation and broad outreach during the preparation and execution of policies and actions. Transparency helps to build mutual trust, avoiding unequal distribution of information, and combatting corruption or other types of harmful influences from certain political pressure groups (Gavin, 2010). Evidence suggests the increasing role of partnerships (public–private and private–private) and nongovernmental actors in areas traditionally governed by municipal agencies (Broto and Bulkeley, 2013).

A valuable resource linked with stakeholder participation is the availability and provision of information (including decision support systems). Enhancing social awareness of and preparedness for climate change (notably climate-induced risks and disasters) is a major goal for communicating information necessary for climate action. Collecting and accessing data for climate change planning purposes – such as vulnerability assessments and GHG emissions inventories, assessment of climate change actions, and monitoring and evaluation – are critical activities that enable planning for climate change. Other aspects include capacity-building (e.g., different types of training), technology transfer (from local to international), networking, and best practices exchange (Greenham et al., 2012).

Financial resources and mechanisms are essential (see Chapter 7, Economics, Finance, and the Private Sector). Mitigation and adaptation projects require mobilizing a combination of financial resources from federal, state, and municipal governments; development banks; private investments; multilateral and bilateral funding; concessional lending; and existing and new climate funds such as the Global Environmental Facility (GEF), Green Climate Fund (GCF), Climate Investment Fund (CIF), and others. On the other hand, there are many examples of successful bottom-up community-based approaches, particularly with regard to resilience-related projects (Smith et al., 2014). Chapter 7 provides a detailed discussion of possible financial resources and mechanisms available for cities to develop climate change actions and plans to address both adaptation and mitigation. Public–private partnerships and private-sector engagement are crucial means for financing the implementation of climate change measures particularly related to capital-intensive, energy-efficient, and climate-resilient infrastructure. Chapter 7 analyzes the opportunities and important issues to be taken into account when establishing public–private partnerships and private-sector involvement in financing climate change actions.

Implementation of climate change mitigation and adaptation actions entails the use of different planning systems, policy instruments, and steering mechanisms. Climate change (mitigation and/or adaptation) actions can be mainstreamed into existing sectoral plans and policies, whereas existing plans and actions in different sectors can incorporate climate change objectives. Actions can be implemented so that urban and infrastructure plans (e.g., for land use, transport, water and sanitation) contain climate considerations. The provision of services (e.g., water, transport) can incorporate low-carbon and climate-proof regulations and specifications. In addition, a special climate change unit can be created within the municipal structure to be held responsible for climate policy (within an existing unit or as a separate unit), or climate considerations can be mainstreamed into a range of municipal units. Examples of the creation of climate change units can be found in Copenhagen, Mexico City, and Durban to name a few. The city may then adopt a Climate Change Action Plan that sets GHG emissions and vulnerability reduction targets. Furthermore, better results can be achieved when there are policies and actions integrated with neighboring cities, harmonized with provincial, national, and international policies (European Commission, 2011; UN-Habitat, 2015) (see Chapter 16, Governance and Policy).

Political brinkmanship also poses a significant challenge to the success of integrated climate policies, leading in many cases to ineffective micromanagement and communication greenwashing. Hence, strong political leadership is required for the adoption of an ambitious integrated climate change program that brings both climate and local benefits (Burch, 2010; Johnson and Breil, 2012; Moser, 2012). Successful experiences include the role of the city mayor as champion of the agenda or a strong city council advocating for climate actions. The cases of Quito and Mexico City are examples of how effective strong political leadership can be in planning and implementing integrated climate change policies (see Case Studies 4.5 and 4.6).

Case Study 4.5 Integrating Mitigation and Adaptation in Climate Action Planning in Quito, Ecuador

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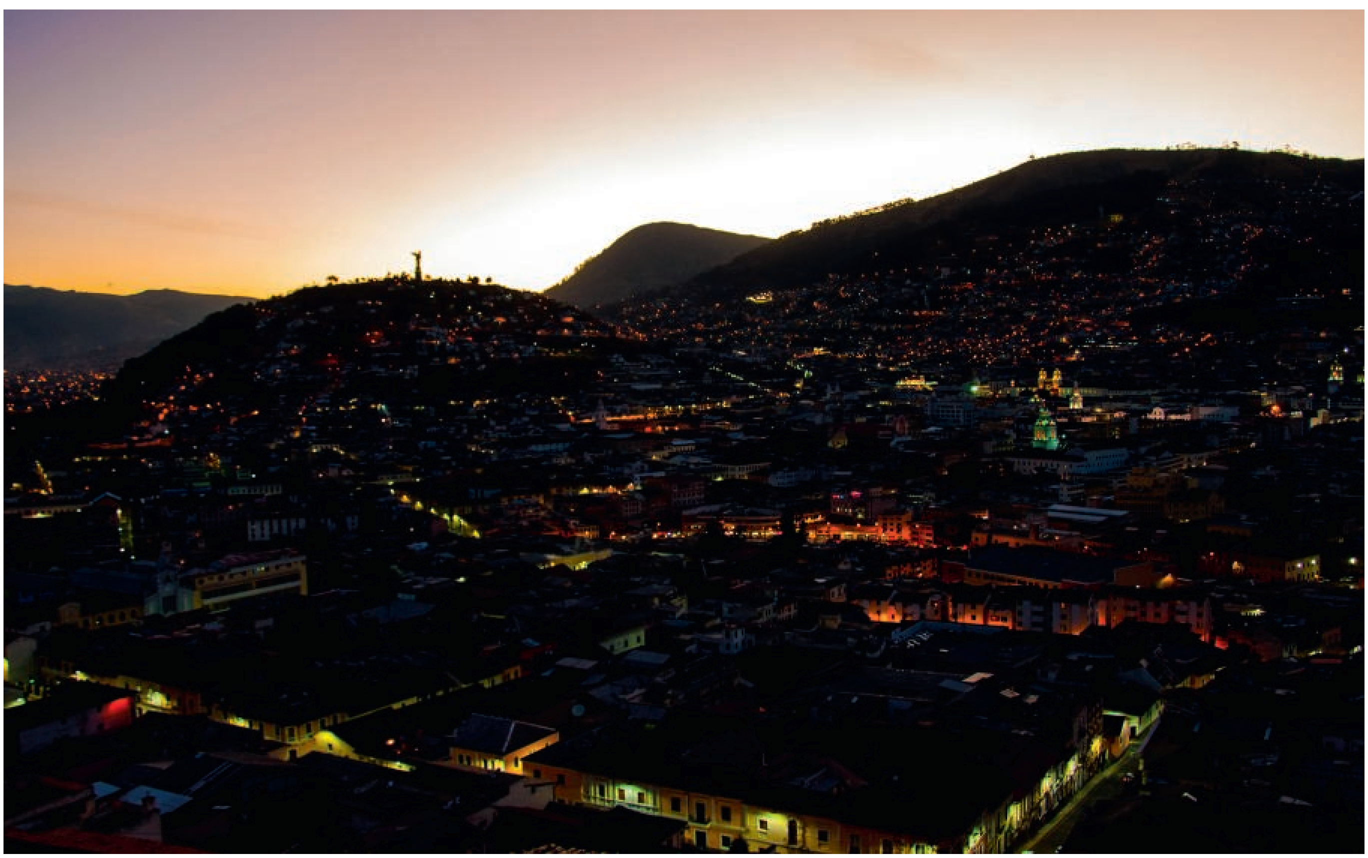
Keywords	Integration, multiple benefits, stakeholder engagement, impact assessment, adaptation and mitigation
Population (Metropolitan Region)	2,365,000 (Demographia, 2016)
Area (Metropolitan Region)	4,230 km² (STHV, 2010)
Income per capita	US$5,820 (World Bank, 2017)
Climate zone	Cfb – Temperate, without dry season, warm summer (Peel et al., 2007)

The Metropolitan District of Quito – Ecuador's capital, nested within the Andes Mountains – is highly vulnerable to the effects of climate change. Between 1891 and 1999, temperature rose by 1.2–1.4°C, which, combined with an increase in the frequency and intensity of landslides, floods, and forest fires, has increased risk for the city (Municipality of the Metropolitan District of Quito [MDMQ], 2012a; Zambrano-Barragán et al., 2011). In recent years, extreme weather events have affected infrastructure, human settlements, agriculture, and forests, while the loss of glaciers and highland ecosystems, known as *páramos*, threatens food security and water and hydropower supplies (MDMQ, 2012b; Rockefeller Foundation, 2013).

In response to current and potential impacts, and with the aim of reducing the city's carbon footprint, the Municipality of the Metropolitan District of Quito adopted a Climate Change Strategy in 2009, followed by an Action Plan in 2012. Although the Strategy made a clear distinction between adaptation and mitigation policies (MDMQ, 2009), the Action Plan addresses adaptation and mitigation in an integrated way. The actions are to be implemented during a five-year period and focus on ten strategic sectors: water resources, disaster risk management, sustainable transportation, agriculture, land-use planning, energy, waste management, industries, health, and ecosystems (MDMQ, 2012b).

Political leadership was the main driver for integrating adaptation and mitigation. In a context of limited financial and human resources, municipal leaders prioritized measures that had multiple benefits (including resilience and sustainable development). This decision not only responded to technical analyses carried out by the Municipality, but was also supported by a diverse group of stakeholders that participated throughout the Plan's design. One of the success factors of the stakeholder engagement process was to allow them to define the criteria of prioritization for the final set of measures that were included in the Action Plan; among the most supported criteria were precisely the capacity to deliver multiple benefits, as well as cost-effectiveness.



Case Study 4.5 Figure 1 *View of Quito*

Integration also offered officials from the Environment Secretariat – the institution that coordinates climate change management and the Action Plan process – the opportunity to mainstream climate change and generate political support across sectors and institutions. During the design process, the lead team analyzed the adaptation and mitigation potential of actions that were already planned by different sectors and promoted the recognition of their climate benefits in the Action Plan and across society. Other institutions saw the added value of their interventions, felt empowered, and supported the adoption of Quito's first Climate Action instrument.

While the planning process helped foster commitment from different stakeholders, integrating adaptation and mitigation has also proved to be a challenge. Actions with multiple benefits were more easily identified in sectors like land use, ecosystems, water, agriculture, and sustainable building, whereas health, waste management, and transportation were more related to either adaptation or mitigation. Moreover, as implementation moves forward, measuring the Plan's impact in a holistic manner is also challenging, In light of the fact that impacts related to adaptation and mitigation vary in temporal, spatial, and institutional scales, it is hard to measure and demonstrate performance *ex-post* (Klein et al., 2007). Communicating impact and defining targets for vulnerability reduction and adaptation are demanding tasks for urban policy-makers, making it a challenge to provide a balanced discourse between adaptation and mitigation.

The new city administration, which took office in 2014, has given continuity to the Climate Action Plan and its integrated vision for adaptation and mitigation. Policies for both an increase in resilience and a reduction of the carbon footprint were included in the new Development and Land Use Plan 2015–2025, and strategic actions with multiple benefits in sectors like sustainable building, water resources management, and land-use planning are being strengthened (MDMQ, 2015).

Moving forward, in early 2016, the Municipality performed an impact assessment and evaluation of the 2012–2016 Climate Action Plan. Based on performance results, and prioritizing on-the-ground implementation, it updated this planning instrument and its GHG inventory before the convening of Habitat III, the United Nations Conference on Housing and Sustainable Urban Development.[1] As the host city, Quito aimed to contribute to the debate on the New Urban Agenda by providing concrete examples of resilience and mitigation policies and actions.

Recognizing the need for further appropriation of climate action by municipal agencies and civil society in Quito and Ecuador in the following years, city officials expect to prioritize replicable, tangible, and visible initiatives. Since communicating the impact of adaptation initiatives in the city remains one of the major challenges, indirect, sectorial indicators are being developed and used to measure success. As an example, the city measured its water footprint and is using it as the base for the creation of a reduction and compensation mechanism by the private sector, the municipality, and other civil society stakeholders.

Although progress has been made in areas like institutional frameworks, information and knowledge, and collaboration for climate action in Quito, their scale and scope are still insufficient. In addition to win-win actions, transformational changes in Quito are increasingly required in sectors such as energy, water, mobility, and disaster risk management, particularly in terms of adaptation so that human rights are upheld. Efforts to promote equity and modify power relations in the city are key for vulnerability reduction and should remain at the core of urban climate action in Ecuador and Latin America.

4.4 Approaches to Integrated Response to Climate Change in Cities

When cities approach adaptation and mitigation activities, they tend to follow, to a large extent, a general planning cycle process. This general planning process for climate change can be found in numerous policy documents and scientific articles (Bizikova et al., 2008; ICLEI and UN-Habitat, 2009; Moser and Ekstrom, 2010; UN-Habitat, 2014, 2015). Based on a review of municipal climate change action plans of cities, planning for climate change in cities usually focuses either on climate adaptation or climate mitigation depending on the local context and city priorities, whereas there are few examples of integrated approaches. Ignoring one of the two agendas might create conflicts between mitigation and adaptation objectives or miss potential but important synergies. If conflicts can be avoided and synergies enhanced by identifying their drivers at the early stage of the planning process, adaptation and mitigation can be successfully integrated into urban planning and implemented in tandem in practice (see Case Study 4.6). Therefore, based on current practices and empirical evidence, we introduce five possible pathways for cities to make decisions and plan for climate change response:

1. *Stand–alone single approach*: Cities develop stand-alone municipal climate change (either adaptation or mitigation) plans, without considering any possible interrelationships (synergies and conflicts) between adaptation and mitigation objectives. This is the general case in many cities, which have largely focused on mitigation only.
2. *Stand-alone parallel/combined approach*: Cities develop stand–alone municipal climate change plans both for adaptation and mitigation in parallel without considering interrelationships between them (e.g., New York, London, Danang).
3. *Adaptation driven with mitigation co-benefits*: Cities develop municipal climate adaptation plans considering mitigation co-benefits and tradeoffs (e.g., Durban, Quito, Vancouver).
4. *Mitigation driven with adaptation co-benefits*: Cities conduct climate mitigation action plans considering adaptation co-benefits and tradeoffs (e.g., Paris, Buenos Aires).
5. *Integrated approach*: Cities develop municipal climate change action plans that incorporate both mitigation and adaptation objectives taking interrelationships into consideration (e.g., Mexico City, Wellington).

1 Habitat III, the United Nations Conference on Housing and Sustainable Urban Development, will take place in Quito, Ecuador, in October 2016. It will focus on the implementation of a New Urban Agenda, building on the Habitat Agenda of Istanbul in 1996.

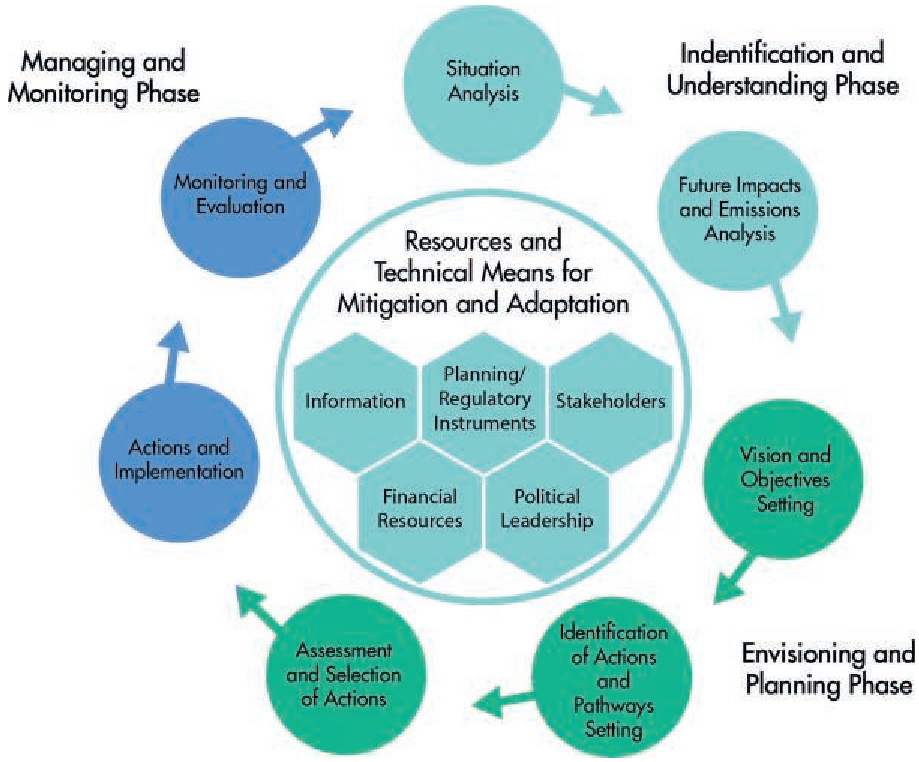


Figure 4.4 *Planning for low emissions development and resilience in cities.*

Source: Adapted from Bizikova et al., 2011 and Moser and Ekstrom, 2010

Next, we present an approach for integrating climate change mitigation and adaptation for metropolitan regimes. We identify, at each stage of the planning process, the challenges and opportunities of integrating climate mitigation and adaptation that are related either to structural conditions or to the availability of technical means and resources (see Table 4.4).

4.4.1 Phase 1: Identifying and Understanding

4.4.1.1 Step 1: Situation Analysis

A starting point in the planning process is the *situation analysis* of the city, considering the current baseline data for multiple variables. This includes the availability and development of datasets for a range of socioeconomic, environmental, climate, and land-use variables. Vulnerability maps (using GIS) and vulnerability indicators at appropriate spatial scales allow for the identification of current climate risk, taking into account vulnerability factors such as exposure, sensitivity, and current level of adaptive capacity. Climate impacts should be differentiated according to their temporal scale: (1) extreme events (immediate and short term) such as floods, heat waves, landslides, and storm surges and (2) long-term (annual/decadal) climate threats such as variations in average temperature or other slow-onset events such as sea level rise.

Simultaneously, sufficiently disaggregated city-level (and, whenever possible, metropolitan-level) GHG inventories are the starting point for urban mitigation measures, characterization of emissions (direct and whenever possible also indirect, e.g., from power generation), adequate sectoral breakdown (e.g., transport, buildings, industries, waste management, land-use change), and activity data that drive emissions (e.g., energy production by different means, passenger kilometers traveled, production outputs, floor space of different commercial facilities, household characteristics, waste generation/recycled/treated), both for community and municipal government. Figure 4.4 addresses planning for these aspects.

4.4.1.2 Step 2: Future Impacts and Emissions Analysis

Climate projections (downscaling based on global and regional climate models) of variables such as temperature, precipitation, and sea level rise are needed to be able to understand the likely range of climate change impacts in cities, address uncertainties, and develop future scenarios (see Chapter 2, Urban Climate Science). Assessment of future climate impacts and future emissions also requires consideration of the current and projected future growth of multiple urban sectors such as infrastructure, transport, energy, buildings, and an estimation of the probabilities of risk outcomes and damages throughout the metropolitan region; and the level of carbon emissions in the various sectors.

Uncertainty of future climate impacts at the city level is one of the main challenges that municipal governments must address. It is beneficial to co-generate the climate modeling risk information with a research center and city agency so that it can be updated and easily used by decision-makers (see Chapter 2, Urban Climate Science). One of the main challenges is the large time-frame discrepancy between climate change projections (e.g., 20 or even 50 to 100 years) and political decision-making (usually about 4 years). However, even in cases of large uncertainty in climate projections or lack of political support for climate change, measures with local benefits can be generated to improve the overall resilience and sustainability of a city to current extreme events, and by extension to future risks (Johnson and Breil, 2012).

Conducting assessments and collecting data for vulnerability assessments, GHG emissions inventories, and modeling of future emissions and impacts scenarios require significant technical capacity and cost. Therefore, lack of financial resources might lead to tradeoffs between mitigation and adaptation objectives for the same limited municipal budget. However, cities have been developing significant experiences in conducting both vulnerability assessments and GHG emission inventories in recent years. Vulnerability assessment often relies on the engagement of different stakeholders to identify the level of risk and the adaptive capacity of different communities, whereas engineers or experts usually conduct a GHG emissions inventory. Conducting vulnerability assessments, GHG emissions inventories, and scenario analysis is by definition intersectoral and participatory. Hence, coordination and collaboration among different city departments and jurisdictions are critical during this phase.

4.4.2 Phase 2: Envisioning and Planning Phase

4.4.2.1 Step 3: Vision, Objectives Setting, and Institutional Set-Up

This step requires creating a vision for the future of the city by identifying development objectives and priorities in the context of current trends and future climate impacts and emissions. This step also helps in the identification of climate change adaptation and mitigation actions in order to meet overall long-term priorities. A clear list of existing city development objectives from other plans (such as the master plan, environmental plan, land use plan, transport plan) and strategies should be used as part of the process. While developing the vision of the city with regard to climate change issues, identifying and understanding different stakeholders' priorities and objectives are also necessary. Furthermore, it requires analysis and understanding of the overall city-level objectives vis-à-vis climate change planning priorities (see Case Study 4.6).

Inclusion of multiple stakeholders at this step is essential for harmonizing different priorities and making the climate change action plan workable, as examples from Mexico City and Quito have shown. One example is Mexico City's Climate Action Plan (2008–2012) that included important environmental synergies with objectives established earlier in the city's Green Plan (2007), but also synergies between mitigation and adaptation actions.

Setting up an institutional and regulatory framework with regard to coordination and collaboration among multiple city departments and jurisdictions is required in order to incorporate the objectives of multiple departments in planning and implementation. The cross-sectoral and cross-jurisdictional relationships might create conflicts in addressing both mitigation and adaptation. Agreeing on specific goals can be challenging, particularly in regard to the differences in spatial and temporal scales of adaptation and mitigation benefits (Moser, 2012).

4.4.2.2 Step 4: Actions Identification and Pathway Setting

During this step, cities should identify possible adaptation and mitigation actions that would meet the vision and achieve the identified objectives. Climate change adaptation and mitigation actions can be policies, projects, programs, and practices that can be undertaken to reduce a city's vulnerability and GHG emissions and develop its capacity to adapt and mitigate. It is very common to identify different portfolios (combinations) of measures in the form of distinct strategies or to explore possible alternative pathways for meeting cities' climate-resilience and low-carbon development objectives (Klein et al., 2007).

Different stakeholders and city departments can identify a variety of actions, and therefore their inclusion is essential. Existing plans that already lay down sectoral actions could help the process of identifying climate change actions (e.g., as done in Quito) (see Case Study 4.5).

4.4.2.3 Step 5: Assessment and Selection of Actions

Technical expertise is necessary to assess and prioritize mitigation and adaptation options while taking into account costs and multiple co-benefits. This is highly desirable but not always possible due to lack of capacity, constrained resources, and the complexity of assessment processes. Based on the type of assessment and information needed, city governments select assessment and prioritization methodologies.

Mitigation and adaptation actions (or portfolios of actions) are assessed against multiple objectives and criteria, whereas tradeoffs between different objectives can be also identified and assessed. These aspects are very relevant when cities assess both mitigation and adaptation actions in an integrated manner. Several assessment methods have been applied in cities to conduct or support urban climate change action plans. Assessment and prioritization methods can be classified as (1) economics-based approaches, including cost-benefit analysis and cost-effectiveness analysis); (2) integrated approaches such as multiple criteria analysis and integrated modeling; and (3) sectoral approaches (Cartwright et al., 2013; Haque et al., 2012;

Case Study 4.6 Climate Action Program in Mexico City 2008–2012

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Keywords	Climate adaptation plan, mitigation, transportation, water management, housing
Population (Metropolitan Region)	21,157,000 (UN, 2016)
Area (Metropolitan Region)	2,072 km² (Demographia, 2016)
Income per capita	US$17,740 (World Bank, 2017)
Climate zone	(Cfb) – Temperate, without dry season, warm summer (Peel et al., 2007)

The Mexico City's Climate Action Program 2008–2012 (PACCM) established two main goals: (1) reduction of 7 million tons of CO_2 equivalent (ton CO_2-eq) and (2) development of a plan for adaptation to climate change (Secretaria del Medio Ambiente, 2012). Although the program included both mitigation and adaptation actions, they were specifically designed to perform their primary objective either to reduce greenhouse gas (GHG) emissions or to achieve greater urban resilience to climate change. However, we can analyze some lessons learned regarding the interaction of both types of activities:

1. Implementation of PACCM led to the creation of a specific department in the government to lead and coordinate the implementation of both mitigation and adaptation actions: the Directorate of Climate Change and CDM Projects. This office was an important base that enabled the city´s government to develop a deep and comprehensive dialogue among all stakeholders that carried out the program. During the program implementation, actions were clearly separated between mitigation and adaptation; however, having both issues integrated within this department allowed us to identify co-benefits very easily, to start new activities and goals, and prioritize and analyze these measures together as a new way of planning.

2. Some PACCM actions that contributed to both mitigation and adaptation are a program to reduce water consumption by 10% in the central government, the improvement of energy-efficient water pumping equipment, a wastewater treatment plant replacement program, and the development of water networks and pipe rehabilitation to reduce leakages. The actions on water management referred to the Climate Action Program in 2012 and achieved a reduction of GHG emissions of 4,670 tons CO_2eq. PACCM actions regarding transportation are the bike-sharing program ECOBICI, the renewal of the public transportation vehicle fleet, and the introduction of electric taxis (Villagran, 2012). Further actions are tax incentives for green roofs, conservation decrees for 33 urban ravines, an urban reforestation program, and a Certification Program on Sustainable Buildings. The actions taken in the context of the sustainable housing programs, the comprehensive environmental improvement project, and social development in housing units were all carried out by the Institute of Housing and the Federal District Social Attorney's Office. They achieved a reduction of GHG emissions of 30,527 ton CO_2-eq by 2012.

Regarding adaptation, a total of 12 strategies were developed. Examples are early warning systems geared toward identifying risks and threats to the Mexico City population, micro-basin management of urban ravines, assistance to people who are vulnerable to extreme climate events such as heavy rains or intense heat or cold waves, epidemiological monitoring, vitalization of native crops to maintain the biodiversity and resilience of agro-systems, and monitoring of forest fires during the dry season by remote sensing detection.

3. PACCM originated the creation and signing of the Global Cities Covenant on Climate in 2010 in Mexico City. This Pact is an international instrument through which currently more than 340 mayors around the world have pledged to take climate action. The pact includes commitments to execute both adaptation and mitigation actions, and the signatories are required to report annually on both types of measures.

4. Mexico City's Climate Action Program was the first plan of its kind in Mexico and Latin America. It was published even before the Mexican federal government had a national plan. That represented an enormous challenge for planning and implementation.

Some of the challenges faced were:

Planning stage: The need to involve experts, officials, and citizens and to standardize and evaluate their proposals was quite challenging. The plan had to be ambitious but feasible at the same time. Many proposed measures were not economically feasible or had not been implemented anywhere before and could not be assessed. Other measures were simple, but it was difficult to consider them at the same level as other more complex ones. Finally, there were cross-sectoral measures (e.g., energy and transport, energy and water) that made it hard to determine which area of government should be responsible for implementing them.

Implementation stage: There was no allocated budget for some of the selected measures and therefore they were not implemented. At the same time, there were other programs that were not initially included in the Plan, but subsequently were devised and implemented successfully.

Monitoring and evaluation stage: One challenge was to involve managers of other departments in achieving the goals of the plan. Most officials realized that the government's goals were of common interest, but in daily life they lost interest or did not prioritize those measures because they had other important things to do. Political leadership shown by the Mayor drove the process of information provision, planning, and implementation of some measures. Meetings were organized as an opportunity to take high-level decisions to fulfill the plan.

Scrieciu et al., 2014; Grafakos et al., 2016b; Walsh et al., 2013; Charoenkit and Kumar, 2014). According to Johnson and Breil (2012) who conducted a study of seven major cities, only a limited number of cases have quantified the costs and benefits of individual projects.

This step requires the collection and development of multiple types of data and information regarding the likely impacts of different climate mitigation and adaptation actions. It further requires technical expertise and capacity that many cities lack. However, in the past few years, a large number of tools and

Table 4.4 *Technical means and resources in different phases of planning for climate change (CC) in cities*

	Identifying and understanding phase		Envisioning and planning phase			Management and monitoring phase	
Technical means and resources	**Situation analysis**	**Future impacts and emissions analysis**	**Vision and objectives setting**	**CC actions identification and pathways setting**	**CC actions assessment and selection**	**CC actions implementation**	**Monitoring and evaluation**
Information	x	x			x		x
Stakeholders	x		x	x	x	x	
Planning and regulatory instruments		x		x		x	x
Financial resources	x	x			x	x	
Political leadership			x	x		x	

resources have become available for cities to conduct prioritization of climate change adaptation or mitigation actions, although few have been developed in an integrated manner to address both. See, for instance, the CLIMACT Prio tool developed by the Institute for Housing and Urban Development Studies, the Climate Filter of the Emerging and Sustainable Cities Initiative by the Inter-American Development Bank, the Urban Integrated Assessment Facility by the Tyndall Centre for Climate Change Research, and the Integrated Assessment tool by the eThekwini Municipality (Walsh et al., 2013).

Building technical capacity can be costly; hence, the lack of financial resources could be a conflict for cities regarding the assessment of different mitigation and adaptation actions. Addressing both mitigation and adaptation objectives could increase the complexity of the assessment process, leading to even higher demand for resources.

4.4.3 Phase 3: Management and Monitoring Phase

4.4.3.1 Step 6: Implementation

Implementing both adaptation and mitigation actions requires the involvement of a range of institutions and departments. Actual implementation of different climate change actions (particularly structural ones) can be financially challenging. Mainstreaming climate actions into existing plans (e.g., sectoral plans) can help to ensure proper implementation and accountability. According to Johnson and Breil (2012), the administrative level of institutional actors involved in urban adaptation planning determines the range, scope, and capacity to trigger implementation. Furthermore, strong political leadership and support for the climate agenda are essential for effective action. Integrating climate actions at the sectoral level within existing policies and plans is an effective way to ensure funding and implementation. Therefore, planning frameworks, stakeholders, and financial resources are important means for effective implementation of actions.

4.4.3.2 Step 7: Monitoring and Evaluation

Monitoring and evaluation systems track and analyze results before, during, and after implementation, enabling improvements and modifications through feedback processes. In this stage, the level of achievement of the climate change adaptation and mitigation objectives is measured through information and data collection for monitoring and evaluation. However, there are major differences in measuring adaptation and mitigation outcomes and impacts (different metrics, time scales, and uncertainties) that should be considered. Monitoring of actions is a challenging task in integrated climate change policy (Grafakos et al., 2016a).

Table 4.4 summarizes relevant resources and technical means that cities can use in different phases of integrated planning for climate change.

4.5 Future Research and Recommendations

Given that climate change planning is a rapidly evolving in cities and that bottom-up actions are going to be an important cornerstone of the future climate regime, there are key knowledge gaps that need to be addressed. The most pressing areas for further research can be grouped under the following headings: (1) integrated assessment methods and decision-support tools; (2) holistic, intersectoral, and nexus studies; (3) longitudinal studies; and (4) basic terminology and the need for structured taxonomies.

4.5.1 Integrated Assessment Methods and Decision-Support Tools

The need to develop integrated assessment methods and frameworks that capture both adaptation and mitigation aspects and user-friendly decision-support tools that address these multiple aspects at different levels of governance is manifested worldwide (see Annex 3, Case Study Docking Station, and Annex 5, Case Study Annex). It is essential that the development of decision-support tools should incorporate the needs of the users and allow broad participation of multiple stakeholders while integrating knowledge and information from different disciplines and agendas. Furthermore, studies assessing the costs and benefits of integrated implementation approaches in comparison to the option of implementing adaptation and mitigation separately will provide useful insights to researchers, policy-makers, and planners. Climate change policy assessments should compare different portfolios of options instead of individual ones and explore their robustness across different plausible future scenarios and outcomes (Scrieciu et al., 2014).

4.5.2 Holistic, Intersectoral, and Nexus Studies

There is a need to better understand how urban system works in an integrated manner from a climate change and sustainability point of view (Sattherthwaite, 2007, Jones et al., 2014) (see Chapter 1, Pathways to Urban Transformation). Most studies to date have been either sectoral or specific to mitigation or adaptation, failing to treat the city as a system to be optimized for better response to climate (Leseaur et al., 2015). Systemic aspects and their climate change potentials in cities are key to improving understanding (Seto and Dhakal, 2014). Therefore, holistic studies and interdisciplinary research frameworks such as urban metabolism studies that explore material flows and mass balances of water, energy, food, and waste provide the knowledge necessary to design and plan climate adaptation and mitigation in cities. Understanding and quantifying the complex relationships at the energy, water, and food nexus in urban areas would help to elucidate the complex interrelationships of climate adaptation and mitigation policies across different urban systems and sectors.

4.5.3 Need for Longitudinal Behavioral Studies

Given the large range of possible factors that contribute to why cities do or do not approach mitigation and adaptation in an integrated manner, it is surprising how few truly global (or even national) studies have been conducted to tease out what is specific to the local context and what is universal. In the field of integrated climate change planning, there is a clear need for larger longitudinal studies that move beyond individual or a small number of case studies to develop a more nuanced understanding of the relative impacts and effects of enablers and barriers to integrated planning approaches (see Box 4.4). It is still an open question to determine the main independent and dependent variables that condition cities' responses to mitigation and adaptation (Dupuis and Biesbroek, 2013). Much of the existing body of research is highly theoretical, necessitating more empirical fieldwork.

4.5.4 Understanding Basic Terminology and the Need for Structured Taxonomies

Integrating mitigation and adaptation requires an extra effort to understand the research and/or policy object (i.e., what exactly is being addressed). The terminology employed frequently varies between individuals because there is very little synthesized knowledge to date, and methods and theoretical frameworks vary widely. There is also little in the way of agreed-upon taxonomies of causal linkages between the various drivers and responses to climate change. Basic questions, such as how to separate adaptation in general from climate-related adaptation; what constitutes effective or ineffective mitigation and adaptation plans, programs, and policies; and how to best merge mitigation and adaptation strategies, have not been resolved. One possible remedy may be to draw on the classificatory sciences to develop more structured taxonomies of key terms and definitions (e.g., what is a barrier, what is a driver, what is meant by synergy, and so on). Possessing a common understanding of basic terminology may help to clarify what exactly is the object of study.

4.5.5 Recommendations for Policy-Makers

In this chapter, we presented the complexity of mitigation and adaptation interrelationships as well as the opportunities and challenges of integrating the two policies and mainstreaming climate actions in urban planning and decision-making. We provide the following recommendations for urban policy-makers:

- *Diagnose key risks and vulnerabilities*: Cities must have an accurate diagnosis of the current and future climate-related risks to and vulnerabilities of their population and territory. Likewise, cities must have sound emissions inventories and emission scenarios to evaluate mitigation potential. The use of scientific tools and approaches are therefore essential, in particular to strengthen the legitimacy for politically sensitive measures or major investments.
- *Start planning and executing programs early in the administration*: City governments are often short-lived. In many countries, municipalities have a three- or four-year period to realize their programs. Therefore, policy-makers should start climate action planning early in the administration term and ensure that enough legal and budgetary mechanisms are available for policy implementation in the medium term.
- *Evaluate and take advantage of resources and technical means at city's disposal*: Economic analysis is necessary to support decisions regarding the most cost-effective measures to reduce GHG emissions and to adapt to climate change impacts. These kinds of studies provide useful insights as well as transparency for decision-making. However, often they fall short on addressing other important aspects, impacts,

and co-benefits that cannot be monetized, such as reductions in air pollution and traffic congestion and the amelioration of ecosystem services; therefore, they should be complemented by interdisciplinary studies and participatory approaches such as Multi-Criteria Decision Analysis.[2]

- *Consider adaptation and mitigation in an integrated manner in climate action plans*: Specific goals, budgets, and concrete measures should be identified and tracked over time. An integrated climate action plan should include a range of mitigation actions in different sectors such as energy, transportation, waste management, and water management, as well as adaptation actions in sectors such as infrastructure, natural resources, and health sectors along with ways in which these actions can create cross-sectoral synergies. Define precisely the key stakeholders and their responsibilities and roles in each phase of the policy implementation process. The action plans should involve the community, the private sector, and universities and the scientific community in the planning stages, and plans must be communicated to citizens to ensure support, transparency, and opportunities for participation. The plan should establish a monitoring system to evaluate the implementation process and to consider the legislative, fiscal, and economic settings required for success.
- *Identify actions and achieve alliances*: These need to mutually benefit city and national climate policies and include financial support and multilateral or international aid and assistance for sustainable development, particularly in cities in low-income countries. It is important that cities coordinate policies and financial efforts with federal and subnational governments, and with neighboring municipal governments, to make sure that the actions to be financed are not contradictory with actions that the province or nation has already undertaken.

4.6 Conclusions

There is a broad range of initiatives and actions demonstrating that adaptation and mitigation are inextricably linked, especially in cities. While the nature of such linkages is clear in many cases, it is yet unclear in other instances. These linkages appear in the form of positive (i.e., synergistic), negative (i.e., conflicting), and "balanced" (i.e., with tradeoffs) interrelationships between the two policy objectives. A clear identification of these interrelationships in policies and actions and their extent is important and should take into account the multiscale dynamics between adaptation and mitigation.

For climate mitigation, key actions are efficiency, decarbonization, improving carbon sinks, systemic intervention such as reducing consumption patterns and urban spatial planning, and local co-benefits. For climate adaptation, the key actions are assessing and reducing risks at the city level, prioritizing options, and allowing for adequate capacities (institutional, financial, and behavioral) to be built, always envisioning a resilience-based perspective for the urban environment.

The structural conditions of cities (i.e., the environmental and physical setting, institutions and governance, economic and financial conditions, and sociocultural characteristics) determine the current context and boundaries of operating systems regarding climate change adaptation and mitigation and how technical means and resources can be used to create opportunities and overcome barriers for integrating them. A holistic consideration and quantification of the costs and multiple benefits of integrating adaptation and mitigation policies in comparison to stand-alone policies is necessary within the framework of municipal priorities, supported by user-friendly, evidence-based decision-support tools.

Recognized municipal climate policies and actions that address both mitigation and adaptation are frequently incidental, often as a co-benefit of the other. When synergies occur, they are usually highlighted as a means of promoting win-win strategies. However, in many instances, the costs of adaptation or mitigation are allocated unevenly, are not well calculated (in terms of magnitude and likelihood), or are simply ignored.

Given differences in the priorities and needs of cities, any attempt at mitigation and adaptation integration should be embedded in the local context. Adaptation and mitigation in low- and middle-income countries should reflect the urban context of sustainable development, where social and economic aspects often have higher priority than environmental objectives. There are very large differences in adaptive capacity between urban areas in different parts of the world. Carbon-intensive and climate-vulnerable infrastructure lock-ins should be avoided as much as possible, and development should aim at measures and investments that allow leapfrogging to more sustainable pathways.

Making a city resilient to climate change requires integrative approaches that account for multiple goals: adaptation, mitigation, and sustainable development. It means avoiding one-size-fits-all solutions. It also means adequately negotiating tradeoffs and avoiding conflicts among initiatives. Making a city resilient to climate change and sustainable also means ensuring reliable and fair provision of services as well as climate change responses.

Annex 4.1 Stakeholder Engagement

This chapter was prepared in collaboration with a multidisciplinary team of scientists and urban policy-makers and planners from cities across the world. In addition to the scientific writing team (Stelios Grafakos, Rotterdam; Chantal Pacteau, Paris; Mia Landauer, Vienna/Espoo; Oswaldo Lucon, São Paulo), the chapter benefited from valuable inputs from policy and planning

2 A consideration of multiple, usually conflicting, criteria in the decision-making process.

Box 4.4 Psychological, Social, and Behavioral Challenges and Opportunities for Climate Change Decision-Making

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Here, we seek to shed light on aspects of behavior by focusing on psychological and social factors that are particularly relevant for decision-making in the context of climate change in cities (World Bank, 2015; Gifford et al., 2011; Kollmuss and Agyeman, 2002).

CLIMATE CHANGE AS PSYCHOLOGICAL, SOCIAL, AND BEHAVIORAL CHALLENGE

Because climate change is a complex phenomenon and long-term in nature, acting on climate change becomes a decision made under uncertainty, one that conveys perceived risks of action as well as inaction. Risk perceptions differ between individuals and are shaped by a person's mental model as well as his or her worldview and core values. A mental model represents a person's thought process of how something works. It is based on incomplete facts, past experiences, and intuition, which are all employed to process new information. People's worldviews relate to social and political power structures (CRED, 2009). For example, if someone believes in a hierarchical world order, they will trust that leaders will make decisions for them and that they should not question the government's way of approaching climate change actions. Values serve as personal guiding principles for people and relate, for example, to the importance of security, financial prudence, and environmentalism. However, even someone who does not value the environment inherently can lend himself to engaging in climate change actions if it is framed as, for example, a national security issue for people with this core value. Using a person's or decision-maker's mental model, worldview and core values can help in communicating and planning for climate change risks more effectively.

Moreover, because climate change can be difficult to understand and even harder to feel given its long-term nature, it is often believed to be a challenge for the future rather than of the present. Here, a number of psychological concepts help explain these dynamics, such as *psychological distance*, the *availability heuristic*, the *recency effect*, and the *affect heuristic*.

Psychological distance applies when the consequences of an action are only felt after a time delay. This results in a perceived decrease in the importance of that consequence (Mischel et al., 1969; Read, 2001). This could be, for example, a factor explaining hesitancy to implement energy-efficiency measures even if they would pay off over the medium- or long-term.

The *availability heuristic* implies that people make likelihood estimates based on the ease with which they can retrieve or generate examples for a phenomenon (Tversky and Kahneman, 1973). This is based on the assumption that the future will be similar to the present or to former experience (Sunstein, 2006). For example, when asked to judge whether the probability of a blizzard is greater for November or January, people will try to recall storms that they remember occurring in either November or January (e.g., by using “on Thanksgiving weekend” or “after New Year's Eve” as mental aids). This rule of thumb works relatively well under static conditions but is often misleading in dynamic environments like a world characterized by a changing climate.

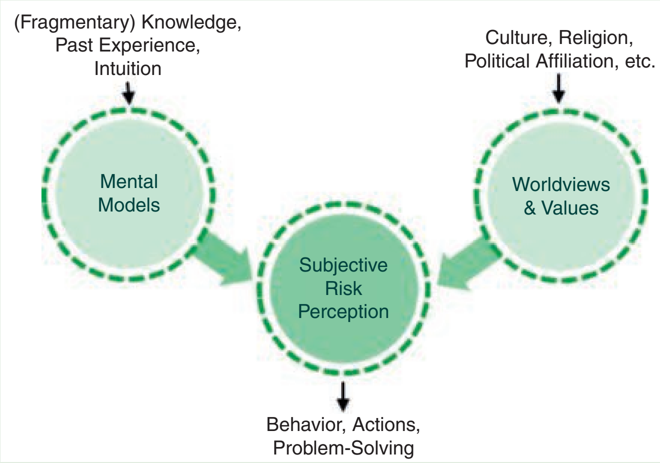
Moreover, not all easily recalled events are similarly likely to occur again. Some easily recalled events may have taken place more recently (*recency effect*) or be associated with strong emotions (*affect heuristic*) because one is personally affected or due to the strong media coverage that particularly high-intensity, low-probability events receive. In such cases, people will remember the event strongly and overestimate its likelihood (Hertwig et al., 2004). Very rare events, however, are commonly underestimated because they have normally not occurred in the recent past (Weber et al., 2004).

These and other psychological effects do not only apply to the perception of climate change, but may also stand in the way of finding solutions to deal with it. In the following sections, we look at five different sectors where a focus on psychological factors could make a difference in acting on climate change.

ERRONEOUS RISK PERCEPTION IN THE RUN-UP TO HURRICANE SANDY

Baker et al. (2012) report the findings of a real-time survey of the risk perceptions of residents as Hurricane Sandy approached the U.S. Mid-Atlantic coast in October 2012. While almost 90% of residents in threatened locations took some preparatory action, this was ultimately insufficient for the sheer magnitude of the storm, which was the second most costly natural disaster to ever affect the United States, after Hurricane Katrina in 2005 (National Oceanic and Atmospheric Administration [NOAA], 2013). Most preparations were temporary, short-term measures, such as stocking up on extra supplies, rather than longer-term or more costly actions like installing storm shutters, developing an evacuation plan, or purchasing flood insurance (see, e.g., Rosenzweig and Solecki, 2014).

A key factor in this ineffective short-term action was the mistaken belief that the area was under a hurricane watch, rather



Box 4.4 Figure 1 *Psychological and social factors that shape people's risk perception.*

Source: CRED, 2009

than a hurricane warning[3]. The day before Sandy hit the coast, only 36% of surveyed residents believed they were under a hurricane warning, and this number rose to more than 50% only on the day of landfall. Many residents remained unaware of the increase in the intensity of the storm throughout the night. Moreover, most coastal residents misconstrued the primary threat of Sandy as coming from wind forces, rather than flooding and storm surge. This may have been affected by how hurricanes are defined – by wind speed – and how most televised weather alerts direct public attention to the track of the storm and particularly its eye. Moreover, much of the information on storms is usually gathered from a single synthesized source that is seen as authoritative, such as television, rather than in a more disaggregated manner from peers or sources such as the Internet. The Internet carries far more detailed information about a storm than that conveyed by television broadcast (Meyer et al., 2013; Morss and Hayden, 2010).

There was also the possibility that the residents' concern may have been dampened by their experiences with Hurricane Irene the year before – 76% of the households surveyed indicated that they had some experience living through hurricanes, although only a minority reported suffering any damage from Irene. Such prior experience can affect the propensity to take action for the next incidence (Orlove, 2011). People had stronger intentions to take protective action if they had less experience with hurricanes (Meyer et al., 2013). Prior storm experience thus can have a suppressing effect.

HOW HOMEOWNERS FAIL TO PROTECT THEMSELVES AGAINST FLOODS THROUGH DISASTER RISK INSURANCE

Insurance is an important mechanism to help homeowners deal with the financial impacts of extreme weather events. However, research has demonstrated that individuals often refrain from purchasing such protection even if reasonably priced. For example, in the United States, many homeowners in flood-prone areas have not purchased flood insurance despite government subsidies. This may be influenced by a difference in the perception of flood risk by residents and the actual risk as calculated by insurers based on hydrological data and models.

One explanation for such behavior is that individuals systematically underestimate the likelihood of rare events, thus not deeming it necessary to protect themselves against them (Browne et al., 2012; Kunreuther et al., 2013). A second reason is the tendency of individuals to buy insurance as a reaction to a natural disaster, even if the likelihood of occurrence does not change or, for some hazards, decreases after an incidence (Kahneman, 2011). Third, if homeowners have not collected on their insurance policy, many do not renew it, considering it a bad investment. The absence of flooding over several years is mistakenly understood as an indication that flood risk has decreased or that the policy was never justified in the first place (Kunreuther et al., 2013).

To deal with these challenges, it is important to develop transparent insurance products and to provide homeowners in flood-prone areas with easy-to-understand information on the likelihood and impact of disasters. Products linking insurance to the property rather than the owners is also recommended because it helps prevent incorrect flood risk perception.

CURBING ENERGY CONSUMPTION BY APPEALING TO SOCIAL NORMS

The right kind of information can also aid in curbing energy consumption. Studies have shown that residents achieve measurable reductions in electricity consumption when they are informed about how much electricity they consume in comparison to others, particularly peers (Allcott, 2011). The best-known large-scale field experiment in this regard was conducted by the energy company OPOWER and included 600,000 households in the United States. As part of this program, residential customers received energy reports that summarized their electricity consumption and compared it to that of neighboring homes with similar characteristics in terms of size and heating technology. Presumably perceiving their neighbors' consumption as a desirable social norm to follow customers after the intervention reduced average electricity consumption by 2% (Allcott, 2011).

PROMOTING WASTE SEPARATION IN HOUSEHOLDS THROUGH MEDIA CAMPAIGNS AND HABIT DEVELOPMENT

Effective waste management is another important determinant of urban sustainability. Most urban waste is brought outside of the cities of origin causing transportation, land

3 A warning means that hurricane conditions are expected, whereas a watch means that conditions are possible (NOAA, 2015). During a hurricane warning, residents are expected to complete their storm preparations and immediately leave the threatened area if directed to by local officials. During a hurricane watch, people are advised to prepare their homes and review plans for evacuation in case a hurricane or tropical storm warning is issued. People are also advised to listen closely to instructions from local officials.

consumption, and greenhouse gas (GHG) emissions. The impact of waste processing could be reduced substantially if organic waste were separated from all-purpose waste and kept in the city of origin for use in urban parks and gardens. In developed countries like Sweden, about half of the garbage (45–55%) is biodegradable material such as food and garden waste (Aberg et al., 1996), which is less suited for incineration due to its high water content. Nevertheless, studies show that neither a pro-environmental attitude nor an increase in information provision alone causes people to separate waste (Chan, 1998; Aberg et al., 1996; Gifford et al., 2011). For example, in a survey in Hong Kong, 98% of the respondents agreed that individuals have the responsibility to protect the environment, whereas only 30% of them separated waste (Chan, 1998). Other studies show that a combination of a pro-environmental attitude, influential social norms, and the person's perception of sufficient influence and control over one's actions are jointly important in generating pro-environmental behavior (Chan, 1998; Fishbein and Ajzan, 1975; Tucker and Speirs, 2003).

However, as with other environmental behaviors, there is a difference between the determinants of initiation and persistence (i.e., starting to separate waste and keeping on with it). Initiation seems to be strongly influenced by the mass media, whereas durability is connected to comfort and daily routines. For the latter, it is important that people perceive separating waste as little a change to former routines as possible. If larger routine changes are necessary, little-by-little changes are preferable. The maintenance of emptying containers is also important because it relates to comfort. People separated less waste when the timing of emptying containers and weather circumstances decreased the rate of composting (and thus increased odors and flies). Moreover, surveys in Hong Kong showed that doorway or curbside recycling was more acceptable than bring systems, and binary waste sorting was more popular than multisorting (Aberg et al., 1996).

City governments can play a key role in increasing environmental awareness for pollution and waste reduction by publicly promoting green behaviors (Chan, 1998). It has been shown that it is particularly beneficial to communicate waste separation behavior as being responsible, rewarding, sensible, and good for maintaining a good place to live. This, together with emphasizing a "feel good factor" when participating in recycling schemes, is believed to be personally rewarding and may ensure greater participation levels (Tonglet et al., 2004). Recycling campaigns should focus on reinforcing the positive attitudes of recyclers and potentially change the negative attitudes of non-recyclers (Emery et al., 2003; Evison and Read, 2001). Research has also shown that economic incentives can be successful in increasing domestic waste separation (Yau, 2010).

PRICING INSTRUMENTS AND CONSUMER BEHAVIOR IN THE PUBLIC TRANSPORTATION SECTOR

Pricing instruments are often an efficient mechanism to reduce demand or modify consumer behavior in the public transportation sector (Eliasson and Mattsson, 2006; Nakakura and Kockelman, 2002; Rotaris and Danielis, 2014). A combination of incentives and disincentives may encourage changes in commuters' travel behaviors, shifting such behaviors from car travel to other modes such as public transport, walking, and cycling (Miyoshi and Rietveld, 2015).

Disincentives to car travel may include fixed tolls, congestion pricing, fuel taxes, parking charges, subsidies, and Pay-as-You-Drive (PAYD) programs. Both fixed tolls and congestion pricing are used in Singapore, London, and Stockholm, whereas Bogota and Chicago use only congestion pricing. New York, Sheffield, and Edinburgh collect parking charges. The congestion pricing program in London – the first in a major European city – started in 2003 and has since then significantly reduced traffic congestion, improved bus and taxi service, and generated substantial revenues. Public acceptance has grown, and there is now support to expand the program to other parts of London and to other cities in the United Kingdom (Mehrotra et al., 2011; Lorenzoni et al., 2007).

In many other cities, such as Los Angeles, San Francisco, Mumbai, and Delhi, transit fares are subsidized. This provides another incentive for car commuters to switch to public transport. PAYD is yet another mechanism to reduce vehicular miles traveled, using insurance premiums based on per-mile charges instead of driving records and other traditional risk factors. This provides motorists an opportunity to lower their insurance costs by driving less, which can benefit the environment (Ferreira and Minikel, 2010). PAYD insurance was introduced in California in 2009 to help reduce vehicle miles traveled and associated GHG emissions.

Bicycling is being encouraged as an alternative urban transport mode in many cities with the aim of reducing automobile dependency and associated GHG emissions. Strategies take the form of bicycle rental stations, being used especially in European cities, and the provision of bike lanes. Although many cities in developing country have a high share of non-motorized transport, this could change with rising incomes. Safety, convenience, and the possibility of improving daily commutes are again important psychological and social parameters. Another noteworthy, low-carbon alternative to car transport is the adoption of bus rapid transit systems (BRTs), as seen in cities such as Mexico City, Delhi, Curitiba, and Istanbul. BRT systems often include BRT-only lanes traveling along established major transport routes and may replace more chaotic, informal transit alternatives that are used in mixed-use traffic lanes (EMBARQ, 2013). BRT systems may offer significantly reduced travel times for passengers (e.g., the Istanbul Metrobüs system, which connects the European and Asian sides of the city, saves an average passenger 52 minutes per day and reduces CO_2 emissions by 167 tons per day; Alpkokin and Ergun, 2012). A well-run BRT system with a high frequency of service, such as the Guangzhou BRT system's 350 buses per hour, may reduce passengers‘ waiting times by a significant amount (Guangzhou Transport Research Institute, 2012). The Guangzhou BRT system was planned together with a bike sharing system along the same corridor, thus offering travelers an even more environmentally friendly option (EMBARQ, 2013). Reduced travel time, safety, comfort, and the potential for increased routine physical activity all serve as incentives to change individuals' behavior.

HEALTH RISK PERCEPTION IN THE CONTEXT OF HEAT WAVES

Heat waves are slow-onset extreme climatic events expected to increase with climate change. In many countries, heat waves put more lives at risk than do rapid-onset hazards like hurricanes, floods, and landslides (e.g., in the United States; Klinenberg, 2002). A number of psychological factors come into play.

Klinenberg (2002) studied the disastrous Chicago heat wave of 1992 that caused the death of 739 people within a week. He concluded that the risk from this hazard had been underestimated due to factors such as the low visibility of heat damage (often only reported as number of excess deaths) and victims as compared with the structural damages that other hazards cause and the subsequent lack of visual and other reporting materials such as pictures (lack of signal value) or tangible experiential reports. The social, economic, and institutional situations of residents also play a role. People living alone, not leaving home daily, lacking access to transportation, being sick or bedridden, not having social contacts nearby, and, of course, not having an air conditioner were found to be most at risk. Older men were at twice the risk of older women due to fewer social contacts, and black communities were more at risk than Hispanic communities.

The case of Chicago shows that heat wave risk has to be taken seriously, particularly in large, dense, and socially differentiated cities. Because communities and residents differ in their coping strategies for heat waves and other risks, community-targeted communication strategies are key. These include sending warnings and press releases through effective media, opening cooling centers and providing free bus transportation to them, addressing residents in risk categories (e.g., by phoning elders or sending police officers/city workers to do door-to-door check-ups on seniors who live alone), or increasing social contact and social embeddedness in communities (Klinenberg, 2002).

IMPROVING COMMUNICATION FOR CLIMATE CHANGE ACTION

In many decision-making processes, perceptions matter more than facts. How we feel about a risk (i.e., our subjective perceptions of risk) influences what we pay attention to in complicated situations and how we approach and solve problems. This can explain the gap between what experts perceive as risk and what the public perceives as risk. Based on utilizing a person's mental model, worldview, and core values, a number of additional aspects can be summarized as aiding climate change communication (CRED, 2009; CRED and ecoAmerica, 2014):

- Climate change communication is best framed in a relevant and relatable way, one speaking to people's worldviews and values, connected to a personal emotional relation, concentrated on positive aspects and potential gains, and formulated in a way that ends with a doable action (i.e., what a person willing to act can do now).
- Communication may generally try to highlight the impacts of climate change that are already being experienced in the present or are likely to occur in the very near future. This will create an urgency to act now (Gifford, 2011). It is also advisable to focus on facts that are assumed to be certain rather than those that are uncertain – for example, the fact that hurricanes with storm surges are highly likely to make landfall in the mid-Atlantic region.
- Moreover, people tend to think that it will be easier for them to act tomorrow or pay in the future – not now – as demonstrated by research on retirement savings (Benartzi, 2012). Applied to climate preparedness or energy conservation programs, participation may be greater if communicators ask people to commit now with the actual or more cost-intensive action being implemented later (e.g., by committing to weatherizing their home in the following year).
- Finally, in any communication, recommendations and/or advice emphasizing local variation can be taken into account to tailor and contextualize information, draw on past experience, and thereby achieve personal relevance with people. It should be kept in mind that different locations and contexts may need different approaches.

practitioners: Patrick Driscoll from Smart Cities Catalyst consulting company, Copenhagen; Martha Delgado, the General Director of the Global Cities Covenant on Climate Secretariat, Mexico City; and David Wilk from the Inter-American Development Bank, Washington D.C. In addition, inputs and advice for the case examples were provided by Sean O'Donoghue, Manager of the Climate Protection Branch in eThekwini Municipality, Durban, South Africa; and Carolina Zambrano, National Representative for Avina Foundation (Fundación Avina), Quito and stakeholders from the energy company Helen Oy from Helsinki.

The chapter writing team organized a special session and roundtable discussion "Integrating Adaptation and Mitigation Strategies in Urban Areas: The UCCRN Assessment Report on Climate Change" (chaired by Stelios Grafakos) at the second biennial European Climate Change Adaptation Conference in Copenhagen (May 12–14, 2015). The purpose of the session was to increase interactions among stakeholders and scientists and engage them in discussions of the experiences of cities from different geographical regions. The session provided insights into key principles when dealing with climate change planning in cities from a mitigation and adaptation perspective and used best practices and lessons learned from different cities. Approximately thirty practitioners, urban policy-makers and planners, researchers, scientists, and private-sector participants attended the session.

Chapter 4 Integrating Mitigation and Adaptation: Opportunities and Challenges

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