

Kerstin Krellenberg  
Bernd Hansjürgens *Editors*

# Climate Adaptation Santiago

 Springer

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## Foreword

The effects of climate change in the Metropolitan Region of Santiago are a concern of the local authorities and there is genuine interest in tackling them adequately. The topic is new, however, and has only recently been considered in Chile. Since advances in climate change predictions in the last few years had not yet reached a regional scale, recommendations on regional adaptation to the adverse effects of such changes were non-existent. Consequently, the German cooperation proposal of launching a project to develop climate change projections and make recommendations for response on a regional scale in the Metropolitan Region of Santiago de Chile gained immediate regional attention and approval. The alliance between the German Helmholtz Centre for Environmental Research and scientific experts from the Pontificia Universidad Católica de Chile, the Universidad de Chile, and the Karlsruhe Institute for Technology was an added trust factor. The ClimateAdaptationSantiago (CAS) project, which was carried out in the Metropolitan Region of Santiago de Chile, is an example of how regional public policies on issues pertaining to climate change adaptation can be encouraged and supported on a scientific-technical basis.

It is important to highlight the way in which numerous regional public and private actors were consulted and participated in the process of disseminating and verifying the scientific advances made in climate change predictions and in the development of suitable adaptation measures. This democratic act lends more weight to the results of the CAS project and helps to generate action, which is the task of public institutions. Validation of public action by a broad range of actors from the private sector, NGOs, environmental organizations, and public institutions facilitates both its effectivity and its implementation.

It should likewise be emphasized that the CAS project stimulated the coordination and organization of public institutions around the topic of climate change. Parallel to project initiation, the Ministry of Environment began to develop its capacity to coordinate public institutions in the context of climate change issues, in accordance with a law passed in February 2010 assigning these competencies to the Ministry. The latter's participation in the CAS project made it possible to put them into practice. At the same time, the Regional Government, the first institution to

embrace the project, created a working group within the Environmental Commission of the Regional Council, entitled the Sub-commission for Climate Change. It was composed of regional councillors and advised by a representative of the Regional Secretary of the Ministry of Environment, a representative of the Regional Government and two representatives of the CAS project. This can be understood as a significant political act, since it allowed for the creation of a permanent working group on the topic of climate change within the Regional Council, the entity that decides on public regional investment on behalf of the Regional Government. Under the aegis of the CAS project, the working group took the decision to follow up on what had been initiated by the project, to incorporate the newly acquired knowledge in regional decision-making, to disseminate the relevant information among the population throughout the region, and to monitor the outcome of the project - the evolution of the Regional Climate Change Adaptation Plan.

Santiago de Chile, August 2013

Rodrigo Robles (Regional Government)  
Osvaldo Aravena (Member of the Regional Council)  
Jaime Rovira (Ministry of Environment)

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## Preface

This book was inspired by the observation that climate change and urbanization are two ongoing and interwoven processes. Given this strong interlinkage, cities around the world have begun to design regional and local climate change strategies with mitigation and adaptation elements to address the adverse effects of climate change. Megacities and large agglomerations play a significant role here as they tend to be key emitters of greenhouse gases and are heavily affected by the consequences of climate change. Many of these same cities have developed innovative strategies and transition options in response to climate change impacts. It is the complexity and diversity of ongoing processes and governance structures, as well as of social and economic heterogeneity that makes these cities an exceptionally challenging research object. A reasonable response to climate change that is also feasible calls for multi-dimensional, multi-level and multi-scale approaches leading to a greater understanding of the complexity of such processes.

This is the fundamental principle of the book. It describes the integrative inter- and transdisciplinary (IIT) approach used in the development of a Regional Climate Change Adaptation Plan for the Metropolitan Region of Santiago de Chile, including concrete adaptation measures and the evaluation and implementation of such a plan at the science-policy interface. The topics addressed are regional climate change, climate change impacts, adaptation needs and measures, and the implementation of these measures at the urban-regional level. The entire “chain” of analysis is exemplified for one case city. It builds on scientific analyses undertaken during a process initiated by social and natural scientists—an intensive participatory process that embraced a wide range of actors and stakeholders from the public and private sectors, civil society and academia, and a mutual learning network across megacities in Latin America.

The book draws on the international research project ClimateAdaptation-Santiago (CAS) (<http://www.ufz.de/climate-adaptation-santiago>), a combined enterprise of two German research institutes of the Helmholtz Association (Karlsruhe Institute of Technology (KIT) and Helmholtz Centre for Environmental Research—UFZ), three partner organizations in Latin America (Universidad de Chile, Pontificia Universidad Católica de Chile, Economic Commission for Latin America and the Caribbean of the United Nations—ECLAC/CEPAL), and the two



main climate change decision-making entities in Santiago de Chile (Regional Government of the Metropolitan Region of Santiago de Chile and Regional Secretary of the Ministry of the Environment). The project involved about twenty-five researchers in Germany and Chile and sixty local stakeholders representing approximately forty different Chilean organizations. Researchers and decision-makers from the cities of Bogotá, Buenos Aires, Lima, Mexico and Sao Paulo also contributed to this inter- and transdisciplinary project, which was carried out between 2009 and 2013.

This book presents the overall results of the enterprise. Although an edited volume, it differs considerably from a collection of papers, since the chapters follow an overarching structure and analysis. Each of the 12 chapters builds on the previous one, providing a coherent picture of climate change impacts and adaptation analysis in urban areas. It develops transferable solution and acts as an incentive to other cities that still face the challenge of designing comprehensive climate change response strategies.

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## Acknowledgements

We would like to thank all those who made the commitment to contribute to the success of the ClimateAdaptationSantiago (CAS) project. Our thanks go first of all to the more than 25 contributing authors of this book.

In terms of the overall process of the CAS project we are particularly grateful to Osvaldo Avarena (Consejero of the Regional Government of the Metropolitan Region of Santiago de Chile), Rodrigo Robles (Regional Government of the Metropolitan Region of Santiago de Chile), and Jaime Roviera (Ministry of Environment), who were instrumental in pushing the process forward on the political agenda in Santiago de Chile.

We would furthermore like to thank the representatives from the public sector, private enterprises, academia and civil society organizations who contributed greatly to the success of the project by taking an active part in the participatory process (the ten roundtable meetings organized in Santiago de Chile). In this context, our special thanks go to Jonathan Barton and Jordan Harris for making their own contacts available and pushing the roundtable process forward locally. In addition, we are immensely grateful to the universities concerned and the Regional Government for hosting the roundtable meetings.

We also thank the participants of the three workshops organized in the frame of the Regional Learning Network for their interest and collaboration. They came from six Latin American megacities to share their experience of climate change adaptation with us. In this regard, special thanks go to the UN CEPAL, who hosted the workshops, not least Ricardo Jordán, Johannes Rehner, Benjamín Infante and Alejandra Pérez.

Sunniva Greve did an incredible job as language editor of the book and we would like to express our special thanks for her patience throughout the process.

The overall production of the book over a period of almost two years would not have been possible without the continuous and outstanding efforts of our colleague Katrin Barth, who tirelessly supported us with editorial work and helpful suggestions. Her contribution was key to developing a coherent manuscript.

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Leipzig, October 2013

Kerstin Krellenberg  
Bernd Hansjürgens

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**Part I**

**Challenges for Urban Climate Change  
Adaptation**

Kerstin Krellenberg and Bernd Hansjürgens

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## Abstract

The introductory chapter focuses on the principal topics and conceptual frameworks to be addressed in this book. Placing urban climate change adaptation centre stage, it provides a general perspective on the relation between climate change and urbanization, and on adaptation and mitigation, highlighting the specific challenges for Latin America and Santiago de Chile in this context. Furthermore it defines the aims of the book and its research approach, and clarifies its essential contribution to current debates on urban climate change adaptation. In conclusion it presents an overview of the subsequent chapters.

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## Keywords

Megacities • Climate change adaptation • Adaptive capacity • Santiago de Chile

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## 1.1 Urban Climate Change and Adaptation Needs

There is a growing consensus today that warming of the climate system is unequivocal and that most of the observed increases in global average temperatures are very likely due to human activity (IPCC 2007, Annex B, Glossary of Terms). The effects of climatological alterations in temperature and precipitation have already been recognized. Uncertainties about the extent of climate change and the magnitude of its impacts at regional and local level, however, still exist. Consequently uncertainty in modelling climate changes and the related impacts is high.

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Interwoven with climate change is another outstanding process: urbanization. For the first time in history and now an upward trend, more than 50 % of the world's population lives in cities. Its distinction as a global phenomenon notwithstanding, urbanization does not take place homogeneously across continents and countries or even within the borders of a single country. Most future growth is expected to occur in medium-sized cities in the developing world (United Nations 2008).

Latin America and the Caribbean, the focus of this book, show an urban population of 77.5 % (United Nations 2008). The countries with the highest percentage of urban population in the region are Chile, Argentina, Uruguay and Venezuela, where up to the latter half of the twentieth century the population was concentrated in a small number of very large cities (Jordán et al. 2010). At the beginning of the twenty-first century, these population density rates gradually decelerated and led to more diversified patterns of urban concentration in the direction of smaller cities (Rodríguez 2008). The region's population nevertheless continues to converge in its principal cities; as economic, political, and cultural centres, they shoulder a heavy concentration of knowledge, capital and human resources. In the year 2000, approximately 20 % of the total population of Latin America lived in cities of more than five million inhabitants, surpassing all other world regions. These populous concentrations point towards another trend: the appearance in the urban agglomeration landscape of megacities with at least ten million inhabitants (United Nations 2008) perhaps the most visible expression of rapid urbanization.

Cities can be climate change culprits and victims simultaneously. They show specific climates, consume much of the world's energy and produce most of its greenhouse gas emissions. As a result of their concentration of people and services, their centralizing of economic power, their infrastructure and their high demand for natural resources (e.g., water, energy, food), cities are also heavily affected by the impact of climate change. At the same time they are in possession of numerous benefits and opportunities for transition, enabling them to address and respond to this impact.

Considerable differences exist, however, between cities of the "global north" and those of the "global south". Whereas the majority of the former are key emitters of greenhouse gas, the latter have already begun to feel the consequences of global climate change in the form of increased risk exposure (to sea level rise, landslides, floods, droughts, heat waves), since population growth tends to go hand in hand with the expansion of urban areas in high risk environments. A number of these trends are exacerbated by high socio-spatial differentiation leading to frequent placing of "the poor" in hazard-prone areas (Sherbinin et al. 2007; Kuhlicke et al. 2012), where living conditions are fraught with danger as a result of using building materials that are inappropriate in relation to coping with hazards. Furthermore, the governance structures of these cities are complex and can therefore amplify or even produce risks to and negative impacts on human security.

The appearance of climate change on the international political agenda produced responses at different levels of governance: global, international, national, regional and local. Given that a specific level of climate change impact is irreversible and the rate of change very slow, CO<sub>2</sub> concentrations are not expected to decrease significantly, even if the world were to suddenly shift to a net zero carbon economy (IPCC 2007).

Hence adapting to the consequences of climate change is vital and in conjunction with mitigation measures a key component of climate policy. Cities around the world have begun to react. Many have become ‘proactive’ initiators of climate strategies, at times moving ahead of national and global agenda-setting, preparing for the risks and opportunities related to climate change, and bundling long-term development policy-making with the climate agenda, including elements of mitigation and adaptation (Berrang-Ford et al. 2010; Heinrichs et al. 2013). Since the beginning of the 1990s, local governments and other urban actors have taken the initiative to adjust their structures, practices and processes in response to changing climate conditions and their adverse effects. Bulkeley (2010) distinguishes two phases of urban response to climate change: a first phase pioneered by local governments predominantly in the global north, which saw the launching of concrete local policy initiatives to reduce the consumption of environmental resources, particularly energy. The second phase, which got under way in the early 2000s, was more political in nature. It embraced a wider array of climate policy issues and has become increasingly sensitive to such concerns as risk and vulnerability, and how to adapt to these factors.

Multiple interlinking processes of climate change now affect several sectors of society simultaneously and, coupled with the complexity of the governance structures involved, call for multi-dimensional, multi-level and multi-scale approaches if climate change in the urban areas is to be met with an adequate response (Seto et al. 2010; Heinrichs et al. 2013).

Adaptation to climate change has been defined by different disciplines in numerous ways (e.g., Smit et al. 2000). The IPCC (2001) describes it as the adjustment of structures, practices and processes to changing climate conditions and their impacts. Klein et al. (2007) state that dealing with adaptation requires an understanding of the vulnerability of societies and ecosystems to climate change impacts, their capacity to respond and the socio-economic costs it entails. The term adaptation used in this book describes the reaction to risks and vulnerabilities of selected key sectors as they occur under climate change. It refers to the adjustment of laws, programmes, plans and measures in order to curb negative climate change impacts at urban-regional and municipal level. In this context, tackling the complexity of climate change and the interweaving processes involved requires cross-cutting action between sectors (e.g., Shaw et al. 2007). Climate action plans and adaptation strategies are some of the activities with the potential to unite sectors and levels of decision-making within the scope of an integrated planning approach (Healey 1992).

While the need for adaptation and the idea of adaptive response action has been widely acknowledged, obstacles to and constraints on adaptation plans, strategies and measures under real-world conditions still exist and hamper their successful implementation. It is at this point that the current book seeks to go a step further: it presents a conceptual framework (cf. Sect. 1.4) that allows climate change adaptation measures to be developed, prioritized, selected and implemented, and subsequently embedded in a Regional Climate Change Adaptation Plan, taking the Metropolitan Region of Santiago de Chile (MRS) as a case study (Krellenberg 2012).

The remaining sections of this introductory chapter stress the role of adaptive capacity as a decisive factor in responding to global climate change (Sect. 1.2). The case study area is introduced in Sect. 1.3, while the objectives and research approach are laid down in Sect. 1.4. The concluding Sect. 1.5 provides an overview of the subsequent chapters.

---

## 1.2 Response Action to Climate Change: Adaptive Capacity as a Decisive Factor

The advance of climate change on the international political agenda has by the same token produced an increase in the number of analytical studies on the topic. Several studies focus on ‘adaptive capacity’, explaining how local governments address the issue of climate change and identifying successes and failures. Here adaptive capacity describes the potential of a system, region or community to adjust to the adverse effects of climate change including extremes (Smit and Wandel 2006). It defines the ability to prepare for climate change risks and opportunities (proactive or autonomous adaptation) and to cope with or adjust to potential and traceable negative impacts (reactive adaptation). Adaptive capacity is thus closely associated with the concept of coping capacity. The latter describes the ability to deal directly with extreme events on a short time horizon, while the time frame of ‘adaptive capacity’ is typically longer and builds, for example, on learning processes (Yohe 2001). Gupta et al. (2010:461) interpret adaptive capacity as the “inherent characteristics of institutions that empower social actors to respond to short- and long-term impacts either through planned measures or through allowing and encouraging creative responses from society both *ex ante* and *ex post*”. This perspective includes an assessment of the extent to which these features enable society to cope with climate change or encourage it to alter such institutions to achieve this purpose.

A number of conceptual approaches interpret the capacity to respond, cope or adapt as a dimension or component of vulnerability (Heinrichs et al. 2013). In one of the earliest definitions of vulnerability, Chambers (1989) emphasizes that ‘capacity’ is merely one element of the dual nature of vulnerability and links it to exposure to the stress of climate events. Others like Bollin and Hidajat (2006), for example, prefer to interpret vulnerability and capacity as separate entities. This perspective is widely accepted in disaster risk research and management practice. It sees capacity as a more independent phenomenon, defining it as the general ability to confront disasters and reduce risks (e.g., UN/ISDR 2006).

As the recent literature on climate change indicates, elements that drive local action—a possible explanation of its potential success—fall broadly into three categories of local adaptive capacity: ability, willingness and the enabling/disabling context (Yohe 2001; Zahran et al. 2008; Burch and Robinson 2007; Tompkins and Adger 2005). Following the IPCC (2007, Annex B, Glossary of Terms), adaptation can occur in different ways and on different levels:

- Firstly, adaptation can be *anticipatory* or proactive, i.e., “adaptation that takes place before impacts of climate change are observed” by preparing for climate change risks and opportunities, or *reactive adaptation*, which is “adaptation that takes place after impacts of climate change have been observed”.
- Secondly, *private adaptation* “is initiated and implemented by individuals, households or private companies”, and is “usually in the actor’s rational self-interest”, whereas *public adaptation* “is initiated and implemented by governments at all levels”, and is “usually directed at collective needs”.
- Finally, there is *autonomous or spontaneous adaptation*, which “does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems”, while *planned adaptation* “is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state”.

The focus of this book lies on the adaptive capacity of urban decision-makers and their ability to act. Here adaptation is based on a science-initiated process (cf. Sect. 1.4 and Chap. 9) and can be regarded as public, planned adaptation. Despite its consideration of current and future climate change effects, this form of adaptation is anticipatory rather than reactive in nature, as current impacts in the study region Santiago de Chile are relatively low (see Chaps. 4–8). The approach takes into account that responses to climate change involve multiple actors and decisions. Advancing the governance of climate change across all government levels and stakeholders is therefore crucial if policy gaps between national policy frameworks and local action plans (vertical integration) are to be avoided and cross-scale learning between the relevant local and regional government departments and institutions (horizontal integration) encouraged (Corfee-Morlot et al. 2009).

In this sense, a multi-level governance approach to climate change response should take into consideration that national governments cannot implement their climate strategies effectively without close collaboration with regional and local governments as agents of change. Hence learning, information transmission and cooperation between cities or regions and national governments (see Chap. 10), and the refinement of coordination across national ministries implementing cross-sectoral programmes, as many climate change policies require, is vital (Corfee-Morlot et al. 2009). All of these aspects have been incorporated in a detailed analysis of anticipatory, public, planned adaptation at urban-regional level for the Metropolitan Region of Santiago de Chile. The case introduced in the following section gives a deeper insight into the study region.

---

### 1.3 The Case Study Region: The Metropolitan Region of Santiago de Chile

Today approximately 85 % of the Chilean population lives in urban centres; close to a third is concentrated in the capital city. The population of the Metropolitan Region of Santiago de Chile (MRS) is estimated at six million inhabitants (INE