ADAPTATION TO CLIMATE CHANGE IN MEGACITIES OF LATIN AMERICA

REGIONAL LEARNING NETWORK OF THE RESEARCH PROJECT CLIMATEADAPTATIONSANTIAGO (CAS)

Kerstin Krellenberg • Ricardo Jordán • Johannes Rehner • Anke Schwarz
Benjamín Infante • Katrin Barth • Alejandra Pérez
(Editors)

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Project Document

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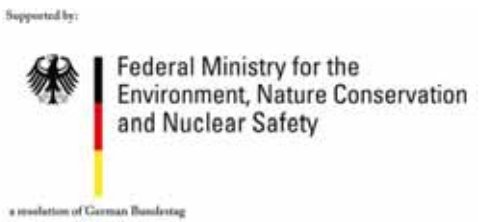

Economic Commission for Latin America and the Caribbean (ECLAC)

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The views expressed in this document, which have been reproduced without formal editing, essentially document the workshops of the Regional Learning Network of the ClimateAdaptationSantiago project and do not necessarily reflect those of the organization. We are grateful for the participation of professionals, academics and political authorities of the six Latin American cities that participated in the Regional Learning Network and who are mentioned in the presentation of this document.

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Presentation

The material compiled in this document is based on the information presented and discussed by experts participating in three workshops forming part of the Regional Learning Network of the ClimateAdaptationSantiago CAS (ClimaAdaptaciónSantiago) project, held in the offices of the Economic Commission for Latin America and the Caribbean (ECLAC), in Santiago, Chile, on 24 and 25 January of 2011; on 26 and 27 of November 2011; and on 11-13 June 2012, respectively. We would like to thank the various scientists and representatives of different institutions for their participation and valuable input in the three workshops: in particular Margarete Amorim, Osvaldo Aravena, Edén Atalaya, Jonathan Barton, Eduardo Calvo, Inés Camillioni, Mónica Casanova, María Clauda García, Sofía Haydee Hidalgo Collazos, Iván Islas Cortés, Andrea Lampis, Gonzalo León, James McPhee, Andrés Flores Montalvo, Diana Motta, Ana Murgida, Gloria Esperanza Narváez Tafur, José Daniel Pabón Caicedo, Ricardo Pereira Leite, Rodrigo Robles, Patricia Romero Lankao, Jaime Rovira, Elizabeth Silvestre, Óscar Vázquez Martínez, Andrea Young and Ana Zucchetti. We are also grateful for participation by the experts from the two centres of the Helmholtz Association involved in the CAS project (the Helmholtz-Centre for Environmental Research, UFZ, and the Karlsruhe Institute of Technology, KIT), as well as the University of Chile, the Pontifical Catholic University of Chile, and the Economic Commission for Latin America and the Caribbean (ECLAC). Furthermore, we would like to thank the various local actors from Santiago, Chile who collaborated in the creation of the Regional Climate Change Adaptation Plan of the CAS project and participated in the third workshop of the Regional Learning Network.

The present text documents the workshops and is not intended to provide a scientific analysis in itself. It is rather a summary of the information and insights offered by the workshop participants, and of the arguments put forward during the discussions, which have been supplemented by the editors. As such, the text includes a partial bibliography to complement the information presented.

For further project information, please consult http://www.climate-adaptation-santiago.ufz.de. The project coordinators are Kerstin Krellenberg and Katrin Barth. The spokesperson is Bernd Hansjürgens and the contact is Kerstin Krellenberg (kerstin.krellenberg@ufz.de).

I. Introduction

A. Analysis of the practice of urban adaptation to climate change in Latin America

The main objective of this publication is to document the current state of urban climate change adaptation practice in Latin America. It is a summary of the three workshops of the Regional Learning Network that was set up under the ClimateAdaptationSantiago project (CAS), encompassing six large Latin American cities (Bogotá, Buenos Aires, Lima, Mexico City, São Paulo and Santiago). It aims to synthesize information on the manifestations and impacts of climate change in those Latin American cities that participated in the network, and above all, governance in the form of concrete actions. The publication is based on information obtained from the participants in the three workshops, but also includes additional scientific input and reflections by the editors. All of this information makes a major contribution to highlighting the different paths these six cities are pursuing in response to climate change. To that end, the publication discusses the various courses of action on climate change adaptation, with the aim of learning from these cases and highlighting practical examples.

There is broad consensus that global climate change is inevitable. Its effects are manifested, among others, in a rise in average annual temperatures, the impacts of which also affect Latin America (IPCC, 2007). Since Latin America and the Caribbean is one of the world's most urbanized regions, urban spaces provide an important research area (Jordan and others, 2012; Heinrichs and others, 2012).

Another important phenomenon is global urbanization. More than half of the world's population now lives in cities, compared to around 30% fifty years ago and just 10% one hundred years ago (UN DESA, 2008). By 2050, the total number of urban dwellers is expected to have grown to 75% of the world's population (UN DESA, 2011).

Urbanization processes are closely related to climate change, since both phenomena impact on urban areas in multiple ways (Solomon and others, 2009). This relationship can be understood as a symbiosis between greenhouse gas (GHG) emissions, climate change, and urban dynamics (see also Sánchez-Rodríguez 2008). While cities produce substantial emissions and thus contribute to global warming, they can also offer significant GHG reduction potential based on a denser concentration of services, and through the eco-efficiency of the infrastructures and technologies adopted. Viewed from a different perspective, cities are hosting large quantities of inhabitants and goods (housing, infrastructure, etc.) that are affected by the impacts of climate change. It was only in the 1990s that cities started to reduce the impacts of climate change and increase local adaptation responses (Cohen

and others, 1998), and this was supported by consensus on the need to act with adaptive policies (Stern, 2006).

Official estimates for Latin America indicate that urban dwellers currently represent nearly 80% of the total population (ECLAC, 2008). Cities are exposed to climate change related phenomena such as flood and extreme heat hazard, drought and landslides, among others (Satterthwaite, 2006; IIED, 2007; Romero and Hardoy, 2011). While climate change is thus viewed as an environmental issue, it is essentially a problem of structural development that impacts the population, requiring a multidimensional approach to elicit appropriate responses to climate change in urban areas. The ability to respond to climate change and its impacts also depends on each city's level of development, political capacity, and spatial context (IIED, 2007). Nonetheless, it can be argued that "the uncertainty of the impacts, the short-term vision surrounding investments and the lack of political leadership and coordination are pervasive problems" (Barton, 2009, p.9).

In terms of urban planning, the failure to adjust zoning and building codes and standards, with a view to the future, could reduce the chances of implementing adaptive infrastructure and thus endanger lives and threaten goods production. As the impacts of climate change may be long-lasting (Habitat, 2011), development programmes, institutional support, and programmes in individual sectors should adopt this multidimensional approach, and integrate climate change responses with other current urban problems in the economic, social and environmental domains (Jordan, 2009), combining a long-term view with specific short-term actions.

To achieve integrated and multilateral cooperation to combat climate change on an urban scale, it needs to be remembered that no mitigation and adaptation policy is equally appropriate for all cities; and policies should stress, support and reward "synergies" and "co-benefits" with other existing policies: for example, how policies can achieve the twin goals of addressing climate change and supporting development (Habitat, 2011, p. 47).

In general, many of Latin America's cities are striving to work with an approach that takes account of both the opportunities and the risks present in a wide range of possible future climate and socioeconomic scenarios. At the same time, the region is expected to implement climate change policies that address problems and needs in both the short and long terms, and include new approaches to support multi-scale and multi-sector actions, to meet the varied expectations of a wide range of participants (Bicknell, Dodman and Satterthwaite, 2009; Habitat, 2001).

This document, prepared from the workshops mentioned above, summarizes the manifestations and impacts of climate change in the six large Latin American cities of the Regional Learning Network participating in the CAS project. In particular, it considers how governance can be integrated through specific actions in the region. Based on all the available information, this publication highlights and discusses the various paths the cities are pursuing in response to climate change, with the aim of learning from the different cases, through specific examples that highlight their respective proposals.

II. Regional Learning Network for climate change adaptation in Latin America

This chapter is an introduction written by the editors of this document to explain the objectives of the Regional Learning Network in greater detail.

A. The motivation for setting up a Regional Learning Network

Approaches to climate change are still based mainly on designing and applying mitigation measures (Sánchez and Bonilla, 2007). Nonetheless, as the risks are likely to become increasingly serious in the future with ongoing climate change and urbanization, this approach will at some point cease to be effective; so the focus needs to be shifted towards one that also delivers short-term solutions, while maintaining a long-term vision: namely adaptation.

With this focus in mind, and given that the Metropolitan Region of Santiago (RMS) is affected by climate change but has still not developed key actions to address the problem on an urban-regional level, the ClimateAdaptationSantiago (CAS) project was developed. This project made a detailed investigation of the expected climate changes and the associated impacts on the RMS; and climate change adaptation measures were developed for a climate change adaptation plan for the Metropolitan Region. This plan was created as part of a participatory process at the science-policy interface (Krellenberg, 2012). All that existed previously was, at the national level, a climate strategy and the National Action Plan (PAN). The latter includes aspects of adaptation, but the focus is mainly on mitigation (Krellenberg and Heinrichs, 2010). The Regional Climate Change Adaptation Plan, the main outcome of the CAS project in late 2012, was delivered to the main entities of the RMS for implementation.

Moreover, since Latin America has many large cities located in different climate zones that are affected by climate change in various ways and are at different development levels in terms of responses to climate change (Krellenberg and Heinrichs, 2010), it was seen as an important scientific procedure to summarize, discuss, compare and present the information on climate change existing in some of the region's largest cities. Accordingly, another important component of the CAS project was the establishment of a Regional Learning Network encompassing the cities of Bogotá, Buenos Aires, Lima, Mexico City, São Paulo and Santiago, with the main aim of knowledge exchange. The

network's main goal is thus to learn from the experiences of other cities regarding adaptation to climate change, including the possible transfer of approaches and successful experiences.

B. Organization of the Regional Learning Network

In order to illustrate and explain the "state of the art" in urban adaptation to climate change and promote the technical skills of decision makers in Latin America, the Regional Learning Network was set up to include both scientists and decision makers in the six selected cities. The three workshops of the CAS project were thus organized with the participation of both scientists and decision makers. The first workshop was devoted to a dialogue between scientists; the second sought to strengthen the exchange between decision makers in the six cities, including representatives of different administrative levels; and the third and final workshop brought them all together. Each workshop had its own theme and focus.

The first workshop of the Regional Learning Network aimed to bring together scientific experts from the six megacities to discuss knowledge on expected climate change and the related impacts in each city (a list of the individuals and institutions that participated in the workshop can be found in the appendix). The workshop thus marked the starting point of the network for knowledge sharing and joint learning amongst the participating cities.

The second workshop focused on a discussion between decision makers in the six megacities, on plans and actions for climate change adaptation in each city (a list of the individuals and institutions that participated in the workshop can be found in the appendix). To take account of knowledge existing at both the urban-regional and national levels and given that not all of the cities have actions at the urban-regional level in place, two experts from each city/country were invited, representing the two levels.

In the third workshop, the decision makers and scientific experts who participated in the previous meetings (together with new participants in some cases, see the participant list in the appendix) as well as local Santiago-based stakeholders involved in the participatory process of the CAS project discussed the key results of the other two workshops and exchanged experiences between science and practice/policy. Participants from both the scientific and the governmental fields attended this final gathering to share knowledge at various levels within and between cities, and thus create a basis for future discussions on climate change adaptation in Latin American cities.

C. Brief summary of lessons learned from the Regional Learning Network

In organizing the three workshops, several key lessons emerged, which served as background information for this document, and will be presented and discussed in greater detail in the following chapters. Three important issues should be noted at this point, as they characterize and influence the development of adaptive strategies:

(a) The interchange between science and practice/policy;

(b) The different practical spheres of action, and;

(c) The institutional framework for adaptation measures.

The interchange between science and practice/policy emerged as a key element of the discussions in the three workshops. To respond effectively with policy instruments, a profound scientific understanding of the manifestations and impacts of climate change is essential. In relation to this information, several common characteristics were identified between the six cities, an important one being the rise in temperature and an increase in the impact of heat waves, although little is known

about the spatiotemporal distribution. What makes this comparison difficult among cities is that the models and methods for downscaling vary in the different cities. Nevertheless, certain problems remain, such as the lack of available modelling of the effects of the urban footprint on the local climate under different climate change scenarios. Moreover, responses of precipitation at the local level are still somewhat uncertain with respect to the scenarios as defined by the IPCC. But most cities project impacts related to the effects of altered water cycles in combination with the land use patterns (i.e. floods and landslides).

The development of specific actions in general is quite varied in the different cities, particularly with respect to climate change adaptation. There is a lot to learn from the experiences and progress of the different cities, and between different administrative levels.

The differences identified between the cities are attributable to the variety of institutional settings. Thus, there are different approaches —from the bottom-up or vice versa, depending on whether there is a general framework at the national level, or whether activities are carried out proactively at the local level. What is common amongst the cities is the need for an integrated, multidisciplinary policy approach in order to respond effectively to the existing complexities.

III. Manifestations of climate change in megacities of Latin America and its impacts

What follows (chapters III, IV and V) is based on the information presented and the opinions expressed in the workshops of the Regional Learning Network of the CAS project (see chapter II and the lists of exhibitors and workshop programmes in the appendix). This text is a summary of the workshops and not an academic paper by the editors. Therefore, the document does not contain bibliographic references for all of the information presented, but it does include bibliographic recommendations of a selection of publications from several of the experts that participated, as well as other authors, at the end of the document. Whenever specific data is presented without a citation, the information was taken directly from the presentations made by the experts from the different cities. In some cases the information is supplemented by the editors from other sources, as identified by their citations.

There is broad consensus that global climate change is inevitable, and that it represents one of the greatest challenges facing the world (IPCC, 2007). Mainly due to the pressures of climate change on urban systems (Habitat, 2011), it is expected that existing risks will intensify in the future. Large cities, however, do not function like ecosystems, and "social systems" generally do not function as natural systems. This report mentions, but does not explore in depth, the social and political processes that play a fundamental role in climate change adaptation - a topic whose detailed analysis is a pending task for similar initiatives in the future.

Owing to the increasing pressures of climate change, an in-depth analysis of the manifestations and impacts of the phenomenon in Latin America's megacities is considered essential. This means that in order to discuss adaptation policies, first of all information on expected future changes at the city level are needed, based on the current climate and a historical data series, a task which includes uncertainties that must be acknowledged. In this regard, existing data on precipitation, temperature and humidity levels are an important part of the background information needed for decision makers; and data availability is an essential component, particularly the frequency, intensity, spatial extent, and the time of occurrence of extreme weather events (IPCC, 2012).

On the global scale, the Intergovernmental Panel on Climate Change (IPCC) has defined a number of different scenarios and the corresponding greenhouse gas (GHG) emissions, in order to provide climate change models based on four evolutionary tracks —economic, social, technological and demographic (see table III.1)— from which four main scenarios emerge (IPCC, 2000).

TABLE III.1
SUMMARY OF SCENARIO FAMILIES (GLOBAL LEVEL)

Scenario Family	Economic characteristics	Social and cultural characteristics	Environmental characteristics (technology and energy)	Demographic characteristics
Family A1	Rapid economic growth.	Cultural mixing. Increase of cross-cultural interactions. Decrease in economic disparity.	Increasingly efficient use of energy and energy materials.	Consistent population growth until mid-century followed by decline.
A1FI	-	-	Intensive use of fossil fuels.	-
A1T	-	-	Balance.	-
A1B	-	-	New energy technologies.	-
Family A2	Slower economic growth.	Cultural division. Development at local level.	-	Consistent continuous growth.
Family B1	Economies of technology and services.	Cultural mixing. Increase of cross-cultural interactions. Decrease in economic disparity.	Use of new clean technologies. Concept of sustainability.	Sustained population growth until mid-century followed by decline.
Family B2	Intermediate economic development.	Social equality.	Environmental sustainability. Slower technological advancement, but more diverse than in B1 and A1.	Sustained population growth, although less in scenario A2.

Source: Summary based on IPCC (2000).

Using the inputs obtained from the aforementioned scenarios, a large number of different mathematical models of global weather conditions (*general circulation models*) simulate with various degrees of resolution the global climate for the twenty-first century (see Table 2 for a selection of models as an example, and IPCC, 2001 for a complete listing of available models from the beginning of this century).

Due to their resolution, the claims and predictions of the general circulation models do not allow for direct interpretations at the city level, as the visualization of a city is well below one pixel in the resolution of those models. Therefore, it is necessary to break down the information to a local or regional level, working with a methodology to downscale the results obtained by the global models in order to quantify climate change at the urban level (the different methodologies are briefly introduced in section B of this chapter). However, in itself, this type of climate change modelling, as well as the process of downscaling the information, generates various uncertainties as the use of different models shows different results for the same variables and scenarios. Moreover, the global models themselves have uncertainties regarding the socioeconomic scenarios applied by IPCC, the resulting emissions scenarios, and the different effects of GHG concentrations. This means that uncertainty is even greater for estimating the impacts at the regional scale. Several major leaps are involved in downscaling a global climate model to local meteorological stations, then upscaling it to an urban-regional level. In general, the problem is in the climate variability that exists between small spaces, especially in the case of cities located in the vicinity of mountain ranges (Cortés and others, 2012).

TABLE III.2
SELECTION OF GENERAL CIRCULATION MODELS

Model	Institution that created the model	Resolution *(in degrees)*
HadCM3	Met Office, Hadley Centre (Great Britain)	2.5x3.75
CGCM3	Canadian Centre for Climate Modelling (CCCMA, Canada)	3.8x3.8
AOM	Goddard Institute for Space Studies (GISS, United States)	4.0x5.0
ECHAM	Max-Planck-Institute for Meteorology (MPI, Germany)	5.6x5.6
ECHAM	National Institute of Geophysics and Vulcanology (INGV, Italy)	5.6x5.6

Source: Cortés and others, (2012: 18); IPCC (2001).

This chapter presents the current state of knowledge on the analysis of climate change in the megacities of Latin America, organized in the following categories:

(a) Current climate conditions and historical data;

(b) Downscaling models and future manifestations of climate change at the metropolitan level;

(c) Impacts related to climate change and vulnerability.

A. Current climate conditions and historic time series

Global climate conditions are characterized by a process that is in permanent flux, but extremely slow-changing. When climate change is addressed in public discourse, it is done in reference to a current process accelerated by human influence, which occurs within a timescale of a few years or decades. Nevertheless, it is a process that is ongoing, which makes it important to begin with a description of current climate conditions, and of the changes observed during the last few decades.

Bogotá

The city of Bogotá is located in the equatorial belt, and its climate is influenced by trade winds and the intertropical convergence zone. The average annual temperature is 13.5° Celsius (C) and annual precipitation varies between 600mm and 1,200mm depending on the location. A central characteristic of Bogotá is its location at 2,600 metres above sea level, in the vicinity of the eastern range of the northern Andes. The region where Bogotá is located is recurrently affected by extreme weather events related to the climate variability associated with El Niño and La Niña phenomena. El Niño brings with it an increase in air temperature and reduced precipitation, while La Niña leads to a fall in temperature and an increase in precipitation.

In Bogotá, between 1974 and 2001 air temperatures increased at an average rate of 0.4°C to 1.0°C per decade, and precipitation showed varying changes of increase and decrease. In general, recorded rainfall diminished until the year 1950; but since then, it has continued to increase alongside temperature increases.

While recorded precipitation levels have continued to rise in the city, the trend in the surrounding environment (the savannah of Bogotá), which is relevant for the purposes of watershed supply and water resources, has been an average decrease of 3% per year each decade. In addition, trends in precipitation within the administrative territory of Bogotá federal district are spatially

differentiated: there are areas with rainfall increases in the north and decreases in the south. However, these trends are overestimates due to heavy rainfall associated with the La Niña phenomenon in the last years (1999-2000) of the time period analysed.

Buenos Aires

Buenos Aires is characterized by a temperate climate with strong oceanic influence, and marked by the predominantly flat topography of the region. It has mild winters (average low in June and July of about 7°C), and hot summers (between November and March the city registers an average maximum temperature of 25°C); and it receives rainfall throughout the year, albeit less during the winter [http://www.smn.gov.ar]. A special feature of weather conditions in the River Plate (Río de la Plata) zone is the existence of the "sudestadas" (strong seasonal winds from the south-east).

For Buenos Aires, meteorological data available for the time window 1959-2009 has been recorded at two stations: the Buenos Aires Central Observatory (located in the urban area) and the Ezeiza International Airport (located in a suburban environment of the metropolitan area). These records show an average temperature increase of 0.20°C per decade in the urban area, and 0.15°C per decade in suburban areas. Minimum temperatures rose by an average of 0.22°C per decade, and the highest temperatures rose by about 0.10°C per decade.

With reference to the urban heat island, the city in winter is always warmer than its surroundings, especially at night. During the summer, a cold island occurs where the city during the day is slightly cooler than its surroundings. In summer evenings the city is much warmer than its rural surroundings. Differences in temperature between the urban heat island and its surroundings can often reach eight to ten degrees Celsius. The trend in recent decades has been towards the reduction of the heat island at night. Two other climate phenomena influence the trends of the urban heat island: an increase in cloud cover at night, and a reduction of wind lulls in Buenos Aires. These complex phenomena complicate future modelling.

Meanwhile, extreme precipitation events (more than 100mm in 24 hours) show a remarkable increase in frequency. In the same 1959-2009 period, the amount of rainfall increased at an average of 13mm/year (suburban station), and 49mm/year (urban station). This difference between the urban and suburban areas is partly explained by the urban heat island.

Lima

Lima has highly specific climate features. It is a desert climate, but with high humidity, and an influence by the direct interaction, within a very restricted area, between the ocean and the high Andes cordillera. Currently in the city of Lima the average temperature is 19°C, with its highest recorded temperature at 34°C, although the high levels of humidity result in the sensation of higher temperatures. The lowest temperature recorded in Lima is 5°C. Despite high levels of humidity, Lima is characterized by desert conditions with a rainfall of 9mm per year, less than that of any metropolitan city in Latin America. As a result, there is a water shortage, and Lima has less water reserves than either São Paulo or Santiago. The most specific feature of Lima is the direct effect of the El Niño-Southern Oscillation (ENSO) on the climate of the metropolitan area.

Observed climate changes during the second half of the twentieth century (1961-2007) show that by the end of the century there were fewer cold days, which is reflected in an increase in the minimum temperature of 0.27°C to 0.33°C per decade. The maximum temperature also rose, albeit at a slower pace of 0.10°C per decade. The number of cold days in the winter has clearly been decreasing, while the low reported rainfall also reflects a declining trend, especially if one compares it to the decades 1930-1950, which saw more precipitation than today.

Mexico City

Mexico City has an average temperature of 15°C, with an 8°C variation between summer and winter. With its yearly alternation between droughts and floods, the climate in the Valley of Mexico

basin has been a key element in the history of the city for centuries. During the twentieth century, temperatures rose by an average of 1.6°C, as a result of changes in agricultural and urban land uses, changes in urban GHG emissions and changes in water supply and drainage systems, all of which resulted in a profound transformation of the hydrological cycle. Also, annual precipitation changed (increases in some regions, decreases in others) across the country, in a range between -4% and +6% per decade. These changes have had significant impacts in the area: the drying of the lake system, the loss of rivers and springs, and more intense and destructive rainfall (Romero Lankao, 2010). This means that key changes in climate parameters in Mexico are not only the result of global transformation processes, but also of regional socioenvironmental transformation processes.

The topography of the Valley of Mexico is highly relevant to local climate conditions, water cycles and the impacts from the surrounding high mountains, which are not adequately reflected in general circulation models. For example, since ancient times, the city has been cyclically subjected to floods and droughts (between 1450 and 1900 the city experienced 136 major droughts).

Santiago

The current climate of Santiago is characterized by hot, dry summers and cool, wet winters, consistent with the definition a Mediterranean climate. The average daily maximum temperature during summer is 28°C to 30°C, while the daily minimum temperature in the winter ranges from 0°C to 5°C. Rainfall occurs mostly during the months of June, July and August, with total rainfall of between 200 mm and 500 mm per year. Snowfall is very rare and occurs mainly in the higher-lying parts of the city. A feature that is relevant to climate modelling is the close relationship between rainfall and elevation above sea level (Cortés and others, 2012).

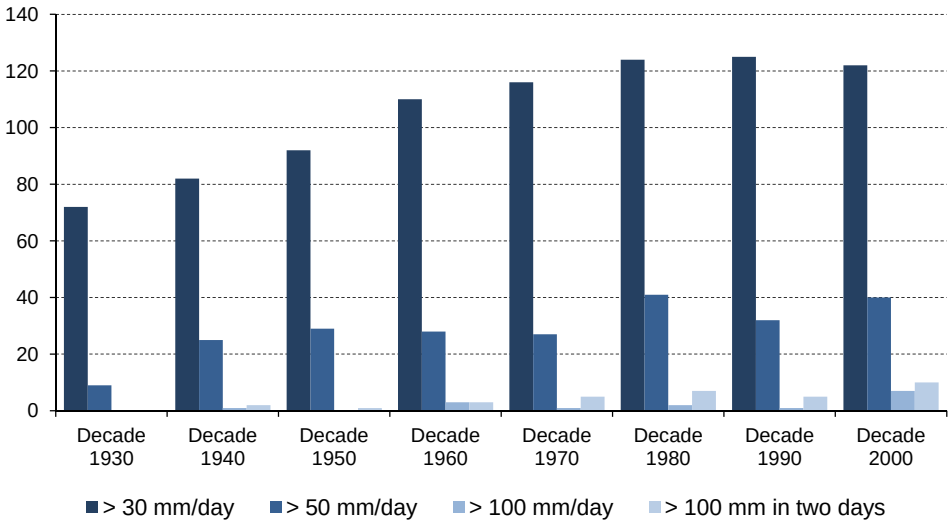
The trends of the past 30 years show a rise in temperature, especially for the stations located in higher areas. This led to a rise in the 0°C isotherm by approximately 150 metres between 1975 and 2001, while rainfall decreased (Cortés and others, 2012).

São Paulo

São Paulo has a subtropical climate, with an average daily maximum temperature above 20°C year round, average daily minimum temperature of about 12°C in winter, and rainfall throughout the year. The period between October and March is particularly rainy, with monthly precipitation of 100 mm [http://www.inmet.gov.br]. Since the 1990s, an increase in the temperature has been recorded with warmer days and nights. The observed increase in the minimum temperature from 1933 to 2009 is 0.29°C per decade, and the increases in the maximum temperature and the average temperature are 0.20°C and 0.31°C per decade, respectively. Total rainfall has also increased and heavy rainfall events are more common, with subsequently fewer, less extensive and shorter-lasting droughts.

The Metropolitan Region of São Paulo (RMSP) suffers from floods every summer, and in recent decades has recorded a rise in temperatures as well as a growing number of hot days and nights, and an increase in the number of days with heavy rain. An analysis of extreme precipitation (days with rainfall exceeding 20 mm, 30 mm, 50 mm and 100 mm/day) shows that there has clearly been an increase in frequency (this level is considered a threshold for rainfall that causes problems), and an increase in the number of days with rainfall above 50 mm/day (a value representing precipitation levels that can be considered a localized natural disaster), as well as an increase in the number of days above 100 mm/day (the amount of rainfall understood as potentially creating more extensive natural disasters). The frequency of days with precipitation exceeding 30 mm/day has increased by almost 40% in the decade of 2000-2009, compared to the decade of 1930-1940. The number of days with precipitation exceeding 50 mm/day increased from an average of 9 per decade between 1933 and 1940 to 40 in 2000-2009 (see figure III.1).

FIGURE III.1
SÃO PAULO: HEAVY RAINFALL FREQUENCIES SINCE 1930
(AGUA FUNDA STATION OF THE IAG-USP)



Source: Agua Funda station, IAG-USP.

The trends shown in figure III.1 incorporate the effect of the urban heat island, which has been accentuated by the acceleration of urbanization. Scientific evidence suggests that global warming, caused by growing concentrations of GHGs, have influenced rainfall amounts and temperature in the RMSP in recent decades, to a lesser extent than local changes, in particular the formation of heat islands due to urbanization, and the changes in land use in general.

B. Downscaling models and the manifestations of climate change at the metropolitan level

Models projecting climate change currently exist on a global scale, and at the level of continents. The spatial resolution of these models are relatively large, typically occupying grids of 50 x 50 km or more (see table III.2), however they have been steadily refined, and today there are also models with a resolution of 20 x 20 km, and even newer models of 5 x 5 km (for example, INPE Brazil). Consequently, it is necessary for most models to downscale the global models, to model and discuss the distinguishing features of climate change across regions or within countries, and to provide an analysis of metropolitan regions in particular. Generally, there are two main methods of downscaling: statistical downscaling and dynamic downscaling (regional modelling). Statistical downscaling is a quantitative procedure that tries to predict the variables of interest at the local or regional level (temperature, precipitation, etc.) based on the larger scale atmospheric variables (Wilby and others, 2004), that is, from the global models. It is based primarily on a statistical process of homogenizing the distribution of frequencies (or probabilities) of the variables of interest. One of its greatest advantages is that it is relatively easy to perform, compared to the general circulation models, which makes it more feasible in the context of regional studies on climate change. On the other hand, it requires a lot of data, such as a series of historical observations, and it assumes that these can be projected to the future (Cortés and others, 2012: 15). The dynamic downscaling models are made by adjusting the general circulation models to regional conditions, generating a complex regional climate model with a far finer resolution (10 km-20 km), but with other theoretical and feasibility constraints (Mearn and others, 2003: 6). One of the best-

known regional climate models is the PRECIS Regional Climate Modelling System developed by the Met Office Hadley Centre [www.metoffice.gov.uk/precis/].

The main objectives of both global and regional modelling exercises are to estimate the likelihood of occurrence of changes in temperature and precipitation based on a database of historically observed data. Through such modelling systems, several trends have been identified that suggest an increase in frequency and magnitude of extreme weather events. However, the discussion on the manifestations of climate change is focused on temperature and precipitation, as they show lower levels of uncertainty. Assertions about the likelihood of future extreme events are of greater policy relevance, although suffering from a higher level of uncertainty than the temperature or precipitation projections of the model. Consequently, this chapter focuses on presenting the information available on temperature and precipitation projections at the urban-regional level. The process of downscaling, which is performed with the available data for climatic and meteorological models in the Latin American cities, usually covers areas larger than just the urban zones. Thus the results presented in this chapter are used to discuss the main features of existing models in relation to the metropolitan areas analysed, although they might represent a larger area that includes provinces and regions.

Bogotá

In Bogotá a combination of statistical and dynamical downscaling (PRECIS model) is used to estimate climate change, especially the A2 and B2 scenarios according to the IPCC methodology for the period 2070-2100. Downscaling is difficult in the case of Bogotá because precipitation trends are spatially differentiated.

In general, it is difficult for the PRECIS model to provide good simulation results for climate data from mountain ranges. Such is the case in Bogotá, which is located in a basin between two mountain ranges that are not clearly represented by the model. The model accurately reflects the weather cycles for the Eastern mountain range, where Bogotá is located, but does not reflect the rest of the geographic environment in the area, for example the Cauca Valley. This complex orography makes it difficult to model the climate of the region where this city is located. Furthermore, with regard to climate modelling for the region, there are difficulties in representing the ENSO (El Niño - Southern Oscillation) cycle, an important element of regional climate variability.

The two scenarios developed based on PRECIS indicate that by the end of this century (2070-2100), changes in temperature in Bogotá could reach +4°C, which means that the average annual temperature could increase from 13°C to 17°C, and that temperatures in the afternoon could reach 27°C-28°C (currently: 23°C-24°C). Some models project a 50% reduction in rainfall from current levels for the same period. There is no clear trend shown towards an increase in extreme rainfall events in Bogotá (rainfall greater than 25 mm in 24 hours). The intensity of the most extreme rainfall events each year, understood as events whose values are above the 99th percentile, show a slight increase of about two millimetres in 30 years. This indicates that changes in the parameters (intensity and frequency) of extreme rainfall events in Bogotá have not been significant for several decades.

There is considerable uncertainty in the simulation of future conditions in Bogotá due to a lack of information. Nonetheless, the city should be prepared for extreme climatic variability not necessarily directly linked to climate change. When comparing the records of the past with future projections, historical data obviously have less uncertainty about the magnitude of the events than that of downscaling projections. That is, it is more urgent to adapt to the extreme variability already registered —such as climate anomalies associated with El Niño and La Niña— than to focus on long-term changes that are still uncertain.

Buenos Aires

For the city of Buenos Aires the PRECIS regional model is also used, which has a resolution of 0.44° latitude x 0.44° longitude. The simulations were performed by the Weather Forecasting and Climate Studies Centre (CPTEC), part of the National Institute for Space Research (INPE) in Brazil.

The emission scenarios that were used reflect the A2 and B2 scenarios from the IPCC (2007). These scenarios are based on three periods: 2020-2029, 2050-2059 and 2080-2089.

For Buenos Aires, forecasts based on the models mentioned above, specifically in the 2020-2029 period, project an increase in the average maximum temperature of between 0.6°C and 2°C. The temperature in urban areas is expected to rise by 1°C in 50 years, and by less in rural areas. The projections in precipitation indicate a slight decline in the first period (2020-2029). After the first period, a considerable increase is projected for all time periods. In the A2 scenario for the period 2050-2059 an increase of 2.9% is expected, and in scenario B2 for the same period, an increase in precipitation of 9.2% is projected. For the period 2080-2089, the projected increase in precipitation is 3.8% for the A2 scenario and 12.5% for the B2 scenario.

In Buenos Aires intense heat waves (with daily maximum temperatures above 34°C) occur not only in summer but also in winter. An urban heat island effect is observed at night in both winter and summer, while cooler temperatures are recorded in urban areas in summer during the day. However, there has been a trend towards the reduction of the nocturnal heat island and a tendency towards cloud formation at night.

As for extreme events, intense rainfall often results in coastal flooding when river levels rise. In recent years there has been an increase in annual precipitation and in extreme rainfall events leading to floods, a progressive increase in the River Plate water levels and an increase in the frequency of the "sudestadas" phenomenon in this area. Also, wind intensity has increased in the river area and wind direction has shifted eastwards. In the 1990s, the average annual intensity of the wind near the River Plate was 1.51m/s. This figure is projected to reach 1.63m/s by 2030, and 1.86m/s by 2070. The frequency of south-easterly winds will increase during this century and, consequently, the frequency of "sudestadas". In addition a rise in temperatures and rainfall has been observed because of the effect of the River Plate, its tributaries, winds, sea level and precipitation. There is no specific projection of extreme events in the city of Buenos Aires.

Lima

Peru experiences high levels of climate variability and is home to 28 of the 32 climate types defined on earth. Lima has a warm climate without tropical heat, with an annual temperature of between 18.5°C and 19°C. It is a coastal city and the second largest city in the world located in a desert (Calvo, 2010). As a result, it is very difficult to conduct a study of climate change in the city of Lima, and the studies of dynamic downscaling that have been performed have applied a spatial resolution of 60 km, which does not reflect the level of variability involved. Generating scenarios is a difficult task because of the extreme variations in parameters. The scenarios for the periods 2050-2059 and 2090-2099 of the models chosen represent the seasonal climatic indicators of the region, but not their variability. Therefore, the model needs to represent both the seasonality and variability in extreme cases, especially for situations relating to the ENSO phenomenon. Assembly modelling has been undertaken in order to acheive representative scenarios. Climate change scenarios were being prepared under the Programme of Climate Change Adaptation (PACC), 2008-2009, and are currently under development.

In Lima, the most likely scenarios are: (i) the "tropicalization" of the city if El Niño were to become more frequent, almost permanent, it would lead to a climate similar to that of Salvador in the state of Bahia, Brazil, with increased precipitation; (ii) extreme weather events could continue to increase in frequency, more of an El Niño type climate, with an increase in heavy rainfall for which the city is not prepared; and (iii) the climate could become more temperate, comparable to the atmospheric conditions seen in relation to La Niña, with lower precipitation and a greater likelihood of drought. In any case, an increase in temperature and higher levels of humidity are expected. In the medium term (2050-2059), a slight increase in rainfall in the Rimac basin is projected, which also means an increase in water availability with respect to the river's water levels. The temperature will probably rise by approximately 1°C, while other models estimate an increase of 2°C to 3°C. Furthermore, the urban heat island phenomenon is projected to become more marked.

It is precisely the effect of ENSO fluctuations and the difficulty of modelling future conditions with any certainty that makes the Lima case problematic and complex with regard to predicting climate change scenarios. Nonetheless, the meso-climatic conditions prevailing in the area allow for predicting certain climate-related risks and extreme events. Owing to La Niña an increase in extreme rainfall is expected. In general, detecting and characterizing extreme events relating to El Niño and La Niña are very important, because these events happen on a global scale. At that level, interactions are taking place between the atmosphere and the oceans in processes that can generate disasters, making such events important to predict.

Mexico City

Climate change scenarios for temperature and precipitation with monthly frequency and a resolution of 10x10km were developed for Mexico City through the virtual climate change centre programme in Mexico City, the Federal District government and the Centre for Atmospheric Science at the National Autonomous University of Mexico (UNAM). To this end, they used four general circulation models (ECHAM5, HADGEM1, GFDL and CM2.0), four emission scenarios (A1B, A2, B2 and B1) and two time horizons (2030 and 2050). They also projected the temperatures and precipitation levels for the Federal District and for Mexico City for 2080 (INE, 2012).

Mexico City is already experiencing certain manifestations of climate change, such as higher average minimum temperatures and increased precipitation levels. Although there are high levels of uncertainty, especially when building climate models with high spatial resolution for the basin of the Valley of Mexico, the average temperature is expected to rise by 4°C by 2080. In the same period, an increase in precipitation levels of around 20% is predicted, to be accompanied by great climatic variability, with intense droughts and heat waves. Mexico does not have the heat island problems seen elsewhere (for example, Buenos Aires), but that effect is expected to worsen. There is particular uncertainty in modelling future precipitation (Romero Lankao, 2010).

When speaking of possible future climate conditions, it is important to keep in mind a number of uncertainties inherent to the development of climate change scenarios, linked to possible future GHG emissions, natural climate variability, and to the models themselves, whose results are subject to very broad ranges of variation. In this context, in the Federal District of Mexico, average precipitation changes in 2050 are expected to fluctuate between -15% and +5% (INE, 2012) (see table III.3).

TABLE III.3
MEXICO CITY: FUTURE VARIATION IN PRECIPITATION AND TEMPERATURE

	Variation in precipitation *(Percentages)*	Average rise in annual temperature *(Celsius)*
Scenario 2020		
Mexico state	Between -5 and -10	Between 1.2°C and 1.8°C
Federal District	Between +5 and -5	Between 0.8°C and 1.2°C
Scenario 2050		
Mexico state	Between -5 and -10	Between 1.0°C and 2.0°C
Federal District	Between -15 and +5	Between 1.0°C and 2.0°C
Scenario 2080		
Mexico state	Between -5 and -20	Between 2°C and 4°C
Federal District	Between -5 and -20	Between 2°C and 4°C

Source: INE, 2012.

In terms of future risks, the changes in climate variability are the most problematic issue. Disasters such as floods, droughts and other hydro-meteorological hazards are expected to continue occurring more frequently; indeed, their frequency of occurrence has already risen from about 10 events per year to 30 per year between 1970 and 2006 (Romero Lankao, 2010). In other words, more droughts, heat waves and short episodes of excessive rain are expected in the future. Of equal importance will be the capacity of the city, its inhabitants and its decision makers to deal with these disasters. This capacity is currently constrained in Mexico City owing to socioenvironmental transformation processes (for example, uneven land compaction due to overuse of water and water scarcity) resulting from unequal access to urban services, income and other asset disparities, and lifestyle choices. These factors hinder civil society sectors in preventing or recovering from damage to their property or health caused by climate hazards (Cordova and Romero Lankao, 2011).

Santiago

The downscaling methodology applied for modelling climate change for Santiago (this work was performed under the CAS project) was done using daily figures from the database of the Coupled Model Intercomparison Project (CMIP3). This is a database of more than 15 global ocean-atmosphere circulation models that were used in the IPCC4 climate change report. Although there are a number of models available, not all were used for data processing because many of them do not clearly reproduce the climate patterns of the region of Santiago. For two future scenarios, A2 and B1, in the time frame 2045-2065, a standard methodology was used, namely statistical downscaling, which is based on the probability of the distribution of each variable. The methodology was applied to temperature and wind, and was slightly modified for precipitation. In the case of temperature, a good representation of the historical scenarios was achieved. However, the downscaling for precipitation was more difficult due to the daily variability. Therefore, the future scenario comparison is made against the modelled base period (Cortés and others, 2012).

Santiago's topographical location in the basin of the central valley between two mountain ranges not only has an effect on the local climate of Santiago, but is also relevant to the modelling of climate change, since the representation of the topography is an unresolved modelling challenge.

The particular seasonality with winter rainfall and prolonged dry summers, has a specific influence on the quality of the models: of the 16 models studied about half do not effectively capture the seasonal cycle with 80% of the rainfall concentrated in three winter months. Some models, which in other contexts are considered the best, do not give reliable results for Santiago in terms of precipitation, for example the HadCM3 model (Cortés and others, 2012).

In Santiago, the predicted increase in average maximum temperature is significant (up to 2.5°C), while the rise in minimum temperatures is smaller, and has a high level of uncertainty. The models do not differ much between the B1 and A2 scenarios (all in reference to the period 2045-2065). However, the number of days with temperatures above 30°C is expected to increase significantly; in some cases, especially in suburban areas, it is expected to double. At some meteorological stations, the number of days with maximum temperatures above 30°C is expected to increase by up to 30%, and most of the stations are indicating a significant decrease in days with temperatures below freezing point. The difference between the scenarios is notable, with the number of hot days being higher in the case of A2 versus B1. Higher temperatures will also bring higher elevations in the 0°C isotherm line, thus increasing storm run-off from higher elevations of the city. Slight increases are recorded in winter water flow from melting snow. However, the water flows of the two main rivers show a general decrease in magnitude (up to 40% in the summer months) due to lower precipitation levels and the increase in snowmelt during winter and spring. In terms of precipitation, there is a general decline (10% to 30%) in all indices of future scenarios. Most models predict fewer days with precipitation and lower precipitation rates on days with precipitation, but the uncertainty is very high (Cortés and others, 2012).

There is a high level of uncertainty with respect to the amount of rainfall in future predictions; however, overall a decline in rainy days is expected and with less precipitation on those days. Total

precipitation is expected to decrease by 30% and water flows in the summer are expected to fall by 20%, as the summer generally has greater average water flow due to the melting of snow in the high basin (calculated on the basis of a hydrological model of the basin) (Cortés and others, 2012).

Regarding extreme events, little is known on the subject. However, forecasts for the period 2070-2100 reveal no increase in the number of days of extreme precipitation, but an increase of extreme precipitation combined with high temperatures, which may reflect an increase in extreme events in terms of water flow. In addition, there is a projected change in the positioning of the isotherm by a few hundred metres above sea level (Cortés and others 2012).

São Paulo

The downscaling model of the National Institute for Space Research (INPE) was developed based on the Eta-CPTEC model, with a spatial resolution of 40km, which is an upgraded version of the 20km resolution. Climate projections were developed for the periods 2030-2040, 2050-2060 and 2080-2090. The prominent effect of urbanization is not incorporated into the current generation of climate projections for the future, which obviously represents a major limitation of the climate projections for the coming decades, given the continuous spread of the urban footprint.

According to the INPE models from 2010 for the City of São Paulo, in the three periods average temperature and precipitation levels will increase. The increase in total precipitation and number of days with heavy rainfall contrasts with the increasing frequency of droughts predicted for the second half of the century. The brunt of the impact of the increased precipitation will hit and is already beginning to be seen in the basin of the Tietê River, where the main flood-prone areas of the Metropolitan Region of São Paolo (RMSP) are located near the Martinal Tietê, Pinheiros and the Tamanduateí rivers.

Another issue to consider is the urban heat island effect, which worsens the situation of rising temperatures in the region, and causes fluctuations in the microclimate. The warmest areas are located in the centre of São Paulo because of the amount of materials that absorb and re-emit heat.

For São Paulo, intense rainfall episodes (over 100mm within a five day period) are expected to increase, despite a projected increase in the duration of droughts towards the end of the century.

Projections of rainfall events, obtained using the CPTEC ETA model for the Agua Funda IAG-USP station, with projections until 2090, show a rising number of events with precipitation above 30mm (five additional days with such events) in the Metropolitan Region of São Paulo and its surroundings. Projections of rainfall over 50mm show an increase of only two or three days. It is important to consider that these increases are much lower than those observed in some weather stations in São Paulo at present.

In terms of temperature increase, using a linear regression to project the mean, maximum and minimum temperatures until the decade 2040-2050, the minimum temperature will increase by 0.3°C per decade until 2050; the mean and maximum temperatures will increase by 0.3°C per decade and 0.1°C per decade, respectively. It seems that the intensity of climate change will be intensified by urban sprawl.

Conclusions on rescaling and estimating the impacts of climate change at the metropolitan level

The following comments are based on the opinions expressed during the discussion of the experts held following the presentations on each city. The views expressed have been summarized and consolidated. For specific summaries of the information presented for each city see table III.4.

- When downscaling at the metropolitan scale, it is recommended to use statistical models that produce results that can be compared between cities. These are the tools suited to climatological studies in urban areas. The process of dynamic downscaling is more

expensive, requires more time and, despite its sophistication, cannot reproduce local phenomena such as heat islands.

- Statistical downscaling can be done only if there is a network of meteorological stations and a sufficiently large data set. Although it is the most recommended methodology, it cannot always be performed.
- Incorporating the new generation of CMIP 5 models within existing models continues to present some difficulties. This new generation has a much finer resolution, which means that it will no longer be necessary to perform the same level of downscaling.
- When creating a model or a platform with comparable models, it is ideal to use the new IPCC scenarios, which will be used over the next seven years.
- Further studies should be carried out on the specific connection between land use, urban heat islands and local climate change. It is also important to develop knowledge about possible changes in the origin of precipitation.

C. Impacts related to climate change and vulnerability

This section summarizes the state of knowledge in reference to the analysis of the expected impacts of climate change in the megacities of Latin America.

It reviews the tangible effects of climate change based on its manifestations in six cities. It explores the consequences of climate change in the spheres of material goods and urban infrastructure as well as economic and social impacts, focusing on the key challenges associated with impact management as highlighted by the experts participating in the workshop. To contextualize the question of vulnerability, the chapter includes a brief characterization of the social conditions in each of the six cities, as they relate directly to environmental and climatic conditions. It has to be stressed that there is no common definition of the term "vulnerability" shared by all six cities. Instead, we present the key vulnerability-related characteristics of each city and their particular connection to the potential impacts of climate change.

Bogotá

The extreme hydro-climatic events occurring in Bogotá include frosts, storms, flash floods, floods, landslides and bush fires. The climate in the plains of Bogotá has an important effect on agricultural production in the area (both within and outside the region) which directly influences food security in Bogotá, certain socioeconomic issues and the availability of water resources, the distribution of pollutants across the city, the pattern of extreme events (heavy rainfall, hail, wind or frost), and epidemiological trends.

Changes in climate patterns pose new challenges, particularly in relation to water availability, the frequency of fires and the related air pollution. These changes will, in turn, engender new patterns of life in Bogotá as a whole, in connection with water demand and supply and addressing the impact of fires.

The main impact of climate change is an alteration in precipitation patterns, and the implications of this for flood hazards. On the side of the Bogotá river basin where the city is located, the scenarios predict reduced rainfall; however on the other side of the basin, where there is greater water flow, rains are expected to increase. Despite this, droughts are not expected, even though there will be more frequent dry periods, resulting in an increased possibility of fires, which could have an impact on ecosystems and, to some extent, the city's socioeconomic system. Nonetheless, periods of heavy rainfall are always to be expected and these will lead the river to overflow periodically. The city's eastern hills could see slightly more extreme rainfall events, which could lead to episodes of widescale flooding.

The health-related impacts of climate change in Bogotá will stem mainly from air pollution caused by a potential increase in the urban heat island and more frequent heat waves. Such events would aggravate the effects of pollution on the human respiratory systems.

Another impact that is generated outside the urban area, but has indirect implications in the metropolis, is the cost of goods and its relation to food security. Since climate change is likely to affect production in the regions that supply the city, rising food prices will lead to reduced access to food for certain segments of the population.

In terms of vulnerability there is significant spatial inequality in Bogotá, combined with inequality in income distribution and in access to opportunities, and a large number of people with unmet basic needs. An approximation of the dimensions of poverty in relation to available urban resources and infrastructure reflects deep inequalities, which raise a formidable barrier to adaptation. The 2008 Human Development Report for Bogotá clearly identified the presence of social and spatial segregation, which is consistent with the concept of "urban divide" discussed in the UN-Habitat report, State of the World's Cities 2010/2011. Despite the persistence of these deep divisions, in the last seven or eight years Bogotá has reduced poverty significantly, thanks to rising income levels and better living conditions. Between 2002 and 2006, the incidence of income-poverty fell from 38.3% to 23.8% (UNDP, 2008). Nonetheless, the level of poverty and the prevalence of precarious housing remain high, especially in the city's outlying areas. This indicates major vulnerability to the effects of climate change; and the statistics on poverty are indicators of Bogotá's highly asymmetric nature. For example, 45%-50% of the city's employment is informal. Studies on social vulnerability have shown that the chronically poor have virtually no assets, while the assets of other poor people are precarious. This fact drives the dynamic in which critical life events have immediate negative consequences on a person's assets and opportunities, which severely undermines the sustainability of people's livelihoods (Lampis, 2010).

Bogotá, (or to be more accurate, Colombia) has one of the best risk prevention systems in Latin America, but it is only weakly linked to urban policies and environmental issues.

Buenos Aires

The current climate conditions in the Buenos Aires region include heat waves, not only in the summer but also in winter. There have been periods with temperatures above 34ºC during the winter (August) in Buenos Aires. There has been heavy rainfall causing flooding, as well as coastal flooding due to elevated water levels of the River Plate. The heat island is a climate phenomenon in itself, based on urbanization or urban land use, and heat waves appear as products of the heat island. The impact of flooding due to extreme rainfall events is great, but if it reaches the higher sectors, the cost becomes increasingly political as a result of the social segregation. Its impacts are appearing in all sectors. There is an expected increase in the frequency and intensity of temporary floods near the river basin due to "sudestadas", but there are no significant extensive floods projected for the area.

In general, the excessive urban heat has had increasingly negative impacts on different sectors (health, energy, etc.). However it is not a major concern in Buenos Aires since urban heat spells depend on the wind and clouds, which in Buenos Aires tend to diminish heat islands. In any case there has been a drop in minimum temperatures, which causes health impacts. Primarily there has been an increase in temperature variability and range, not a generalized rise in temperatures, since, unlike the situation in Lima, the climate in Buenos Aires is not becoming an increasingly tropical. Specific hazards are flooding, water, air pollution, noise and soil pollution. In addition, a long term hazard is the threat of repeated flooding and the reactions to this threat, which result in eutrophication and pollution. There is also an expected increase in flooding. The difference is that in the case of Buenos Aires there are two types of flood events, those caused by increased precipitation, and those caused by the particular extreme events known as "sudestadas".

One aspect of vulnerability that is deserving of further research is the spatial component of inequality in Buenos Aires. Although poverty and inequality are not new phenomena, they have risen to unthinkable levels in the past few decades owing to widespread poverty, the increasing number of marginalized people and profound social inequality. Despite high rates of development, there are large sections of the city with low socioeconomic levels. This is mirrored in the powerful processes of social exclusion at play in the metropolitan areas and the significant intensification of these problems, for example, the population living in informal neighbourhoods has doubled.

The densification of buildings and the reduction of green spaces and woodland areas in the city reflect the uneven socio-spatial pattern, with certain populations hit harder in terms of the effects of climate change (heat islands and more frequent floods).

It is therefore important to consider the different types of vulnerability:

- Physical vulnerability: sanitation networks, power grids, the paved road network, the network of public transportation, housing and public spaces;
- Social vulnerability: high illiteracy rates, low levels of health-care coverage, large populations with unsatisfied basic needs, a high level of youth vulnerability and population dynamics;
- Institutional vulnerability: little or no interaction between the city's administrative units.

An area of focus is the increased likelihood of flooding in the lower basin of the Matanza-Riachuelo and Reconquista rivers due to climate change, and its relation to the spatial patterns of population settlement in social terms. The areas with a high probability of flooding are largely low-income areas.

Intense rainfall events are associated with increased vulnerability due to urbanization and infrastructure deficiencies. Road paving in urbanized areas leads to faster storm run-off, and eliminates the retention capacity of the soil. Inadequate hydraulic capacity in the rainwater drainage network results in an urgent need to efficiently handle the excess run-off.

Lima

In Lima, hot spots change abruptly. The number of automobiles in Lima generates a thermal inversion phenomenon with temperatures in hot spots rising by 1.2°C, but there have also been records of temperature cooling. In the summer, there is a lower concentration of sedimentable dust, which builds up in the city and whose influence can be seen in the Andes Mountains. The cold months are becoming warmer. The frequency of hot days has been increasing with time, along with the number of heat waves. The impact of climate change in Lima is generally related to the temperature of the sea's surface.

Issues relevant to the discussion of territorial vulnerability are directly related to the vast extension of the urban area, and its rapid spread in recent decades. Lima has moderate human vulnerability, and has a relatively high human development index (0.66), but with very marked spatial disparities. A high percentage of the population is located in districts that will be most affected by multiple climate hazards, displaying between one and six types of hazard, according to a map of human vulnerability to multiple climate hazards.

In response to the increased monthly, seasonal and annual precipitation levels in a city with no stormwater systems, with flat roofs, and virtually no capacity for handling rainfall, a directive was issued instructing that roofs should be built with a minimum pitch of 5°C to prevent leaks. Serious problems with slopes, dangerous roads, and the vulnerability of the city's water and electrical systems are exacerbated by heavy rainfall and yet at the same time the city is also being hit by several droughts a year. The tropicalization of the climate threatens the health system due to the increased prevalence of diseases such as malaria and dengue fever.

The city's infrastructure is considered highly vulnerable, in particular the road and water infrastructure. The high dependence on hydro power for electricity is a source of vulnerability during the several droughts experienced each year. Current and future water scarcity is an even greater risk given the growing population, and indeed has already become a reality. The critical situation of the water supply is compounded by the lack of coverage of water-related services: one million inhabitants of Lima are not connected to the potable water network, and sewerage coverage is 86%. The leakage in the water supply network is also very high at an estimated 36%.

Mexico City

On the backdrop of projections of lower rainfall, water scarcity is expected to intensify in Mexico City, which could challenge a water supply system that is already being outpaced by the city's growth. At the same time increased flooding is also expected, due to more frequent extreme weather events, specifically heavy rainfall (rainfall intensity), and pollution.

More frequent floods are expected to have a major impact on physical structures (damaged or destroyed dwellings), livelihoods and the population's health. The population with lower socioeconomic status will be hit hardest by subsequent water shortages and the infiltration of contaminated water in the city and in vulnerable households.

The biggest issue due to the expected impacts of climate change in the city must be understood in the context of the historical problem of water in the Valley of Mexico. Water stress in certain areas in Mexico City is a huge problem, resulting in water scarcity. For decades it has been necessary to bring water from distant river basins. Furthermore, the basins that supply water to the Valley of Mexico are also subject to serious water stress and face deforestation. Public policy for both local and federal water issues in the Valley of Mexico has not been optimal. It will be further exacerbated by climate impacts as major changes in rainfall patterns are expected. It is expected that in Mexico City a more intense hydrological cycle will generate more intense precipitation, but also droughts. This means more run-off and increased evapo-transpiration for a time, and then increased flooding, while at the same time, there will be increased water scarcity. The city is vulnerable in terms of access, use, and extraction of water. Water extraction has resulted in the overexploitation of the aquifers, soil compaction and subsidence, which affect drainage and other urban infrastructure.

Mexico's success in reducing air pollution has been challenged by urban growth, the expansion of urban transport and higher temperatures, all of which exacerbate the impacts of pollution. Heat waves will become increasingly common, but will be relatively less significant than in other cities, as there is a mountainous environment in the vicinity of the city which produces a cooling effect during the night. The population's exposure to air pollution does not vary according to different socioeconomic status, though higher socioeconomic groups have better means of addressing the risks.

The city's vulnerability is defined by its urban policies and urban development. During the postwar period, Mexico City enjoyed policies that resulted in good urban drainage and other services such as water supply. Since the 1980s, the quality and coverage of such services have deteriorated. Problems with leakages and faulty drainage have affected the poor and, to a much lesser extent, the middle class. Such problems have caused flooding and large-scale economic losses.

Weak infrastructure is not necessarily a greater problem in areas with fewer resources. To understand the ways in which Mexico City is vulnerable to the effects of climate change, one must consider the characteristics of the hazard, the characteristics of the different types of hazard exposure (who is located where), and socioeconomic characteristics (access to assets, property and options). Mexico City does not show very strong patterns of residential segregation, rather there is a patchwork of more affluent areas (along the Reforma and Periférico Sur areas) and relatively more vulnerable areas (towards the east and in the city's informal settlements). The city's water-related problems demonstrate the connection between the historical processes of transformation, power and access to the city's resources, and shed light on the issue of vulnerability.

Santiago

Like Mexico City, Santiago faces a decrease in precipitation, but more frequent extreme events: increased flooding, on the one hand (Krellenberg and others, 2013), and more water shortages on the other. The greatest impacts of climate change are expected to be on the water cycle and the use of water as a resource. Projected water scarcity is expected to cause seasonal problems with electricity supply. In addition, the projected increase in extended rainfall may cause flooding in the city. Urban heat islands will also be a problem, especially in lower income areas, with consequences for health.

The main issue in Santiago is water stress and the prospect of water shortages as a result of climate change. Beyond the immediate problem of water supply, water stress will also impact on other areas of urban life due to the commodity's pricing structure. People with fewer resources will have more trouble adjusting, for example, to a sustained rise in the price of electricity and to sharp increases in the prices of food, vegetables or other produce. As the availability of water decreases, it will affect agriculture, especially food production.

Against the backdrop of Santiago's highly segregated layout, there will be differences in the exposure of diverse socioeconomic groups to hazards such as flooding and heat stress due to urban heat islands (see Krellenberg and others, 2013). Water scarcity has already begun to affect the city. In general, low-income areas have been the most affected, demonstrating the link between climate change and the problem of equitable development. Because of this problem, adaptation efforts have focused on an intersectoral and comprehensive approach. However, it is noteworthy that in the case of flooding, even the highest socioeconomic strata are exposed (see Krellenberg and others, 2013).

São Paulo

In São Paulo, higher rates of precipiation, specifically heavy rain, is expected to lead to increased flooding, as has been observed recently. Also a greater urban heat island effect is expected, most likely exacerbated by urban expansion. Land use, in particular the densification of construction developments, is directly linked to both flooding and heat islands.

A peculiarity of São Paulo is the high urban density in the basin, and the increasing expansion of the urban area in conjunction with climate change events with large amounts of rain. This is crucial when analysing the possible impacts of global warming and issues of vulnerability regarding extreme events. In the case of the metropolitan area, the drainage system has an important role because of its negative impact, and because finding a technical solution is difficult. The situation becomes worse as the stormwater is channelled, and consequently floods in recent years have increased in frequency and intensity, despite many attempts at intervention.

Although floods in the Metropolitan Region of São Paulo (RMSP) have the most direct impact on the more vulnerable socioeconomic groups, they do affect the population as a whole. Any citizen can be affected by the indirect effects of flooding, such as traffic jams caused by roadways blocked by floodwaters. The worsening drainage problems in the city have always been linked to the valley floors and poor environmental quality of urban spaces due to the removal of vegetation, the creation of impermeable surfaces and construction directly in water courses.

There is a major risk of landslides, which start on the mountain slopes. The urban environment of the region has changed considerably, resulting in continuous expansion of the urban sprawl. Areas at risk of landslides are mainly concentrated in zones that have been urbanized during the last three decades, and areas more susceptible to landslides are located in the peripheral areas of São Paulo. These all have a similar topography: slopes and areas on the tops of mountains. In denser urban areas with similar characteristics it is possible to control the risk. Another significant impact of climate change is flooding. The hazard is expected to increase, but the amount of flooding could be reduced by measures that are currently being taken. In terms of temperature, in the city of São Paulo an intensification of heat islands can be expected, exacerbating health problems for the population, which will be further worsened by increasing air pollution.

Socio-spatial segregation, the high incidence of poverty and poor housing in some areas increases vulnerability in certain areas of the city. When this coincides with the (informal) settlement of areas that are extremely exposed to hazards, it creates zones that are at high risk from climate change effects. Urban expansion and population growth contribute to putting even more pressure on these spaces.

Approximately 30% (2.7 million people) of the population of the city of São Paulo lives in favelas, marginalized neighbourhoods or substandard housing, often in illegal settlements. The risk of landslide is significant in such areas.

Many problems are created due to improper land use. If urban areas continue to grow unchecked, floods and landslides will exacerbate the problems. The housing shortage and the difficulties of access to land are aggravating these problems. Lower income families end up occupying the city's most remote areas, usually in areas under environmental protection, which should not be inhabited because of the specific topography. Urban informality creates greater risks due to the construction in unsuitable areas, and the reduction of vegetation cover resulting from the construction process. This, in turn, results in floods and landslides in the event of heavy rainfall. One response may be for authorities to repossess the land and carry out impact studies to achieve proper urban planning.

In a study of rainwater run-off based on the characteristics of the city's topography, researchers identified the main areas subject to flooding and landslides. Areas most prone to flooding are completely impermeable and include densely built riverbank areas. In terms of vulnerability, it is important to relate the probability of flooding with health concerns. Flooding generates health risks when unclean waters infect local rodents, thus increasing the incidence of leptospirosis. Existing health data show that the areas most prone to flooding are also those areas at risk for leptospirosis.

To analyse the risk of landslides, precipitation patterns were studied, based on the intervals of occurrence of daily rainfall totals compared with the thresholds of 100mm/day. These were cross-referenced with the characteristics of the area's topography and land use. Experts from the Institute for Technological Research (IPT-SP) gave a different weight in combining these factors, integrated through a decision tree and applied to certain algorithms.

Road infrastructure is highly vulnerable and there are other issues that cannot be expanded upon here (such as quality of life, censuses and participatory analysis). One sectoral study examines nationwide data organized by topic, such as production lines, and agriculture.

Reflections of the final discussion on climate change impacts and vulnerability

The following comments are based on the opinions expressed during the panel discussion of the experts held in the workshop following the presentations on each city. The views expressed have been summarized and consolidated. For specific summaries of the information presented for each city see table III.5.

- Differentiating between the physical, social and economic impacts of climate change calls for a comparative record of vulnerability and a spatial representation of associated indicators;
- There is a lack of research into the deep-seated societal triggers, the role of political power, the intentions behind the urban spatial configuration and its impacts in connection with climate change. Studies must adopt comprehensive and multidisciplinary themes to incorporate these dynamics;
- Further studies are also needed on systems of association (social organizations, standards, institutional environments) and on adaptive systems, such as the practices of appropriation of resources and their everyday use.

Vulnerability

- Vulnerability is a complex variable related to the interaction between exposure, susceptibility and the resilience of societies. It implies a loss of assets and resources, and therefore the loss of the capacity for adaptation. In this context, the concept of vulnerability refers to the social, environmental, economic and institutional conditions that determine whether a society has the capacity to prevent damage or is condemned to suffer the consequences.
- The current absence of a theoretical framework and common methodologies to allow comparisons between studies make it difficult to draw comparisons between cities. Therefore, it is important to clarify the conceptual connection between vulnerability and risk.
- It is important to underline that each different discipline addresses the problem in its own way. The main difference is between the basic scientific approach, focusing on the risk and the external conditions of climate change manifestation, and that of the social sciences, where the focus is on the internal conditions affecting the units of analysis (individuals, communities, etc.), as well as the drivers of those internal conditions.
- In the field of research on adaptation to global environmental change there is a relatively new approach to investigating the interactions between anthropogenic and physical systems, such as cities.
- The problem is that there is a division between basic and social sciences on how vulnerability is defined, and no clear agreement on what is really important in this context.
- In physical systems, the power and the role of the actors in charge have a lower significance than they do in social systems. However, reducing the latter to a model involves the risk of not fully understanding the dynamics of the social systems at play in order to oversimplify conceptual structures, which is detrimental to addressing adaptation.
- Vulnerability depends, among other factors, on individual characteristics, the type of terrain, the security of livelihoods and personal achievements.
- Low-income social sectors have higher rates of vulnerability, but they have other mechanisms to address risks that threaten social capital. Communities with greater resources move their networks when crisis hits, while those with fewer resources sell their assets. Aside from their reactions to crises, different socioeconomic strata also show marked differences in access to services and environmental resources, such as green areas, housing, water and energy.

D. Reflections on the manifestations of climate change in metropolitan-scale policies

Considering the information presented on the manifestations and impacts of climate change in the six cities and the final discussion of the first workshop, there follows a summary of the policy actions needed to adapt to climate change. This summary was used as the starting point in the second workshop with decision makers.

- Despite the limitations and uncertainties concerning the specific characteristics of climate change and its impact on urban areas, policies have to be defined on the basis of currently available knowledge. A review of the methodologies and meteorological models to understand the local climate in metropolitan areas of Latin America and the Caribbean reveals both the possibilities and the limitations of scaling down global

models of climate change. The methods used to rescale global climate models vary from city to city, but common problems in downscaling persist, including the difficulty of representing mountainous areas, and modelling the effects of the urban footprint on the local climate under different climate change scenarios. There is also uncertainty as to the projected impacts of climate change on urban areas. Although downscaling methods may improve, many of the current challenges in data collection and organization will persist. This makes it essential to adapt to climate change using the knowledge that is currently available.

- It is necessary to incorporate adaptation issues in climate change strategies, and to create integrated policies that have to be prepared on a multidisciplinary basis. Specific climate change adaptation measures are also needed, especially in view of effects on public health. Issues relating to land use need to be included in the discussion of climate change adaptation, because important variables, such as air pollution, are altered and intensified by types of land use, and by contaminants related to different urban functions. Furthermore, with regard to residential land use, future residential urban planning must consider adaptation to climate change, for example through eco-efficient homes designed specifically to cope better with heat episodes.
- The impacts of climate change in cities, specifically those related to extreme weather events, not only demonstrate the different types of vulnerability, but also the need for preventive policies, to reduce vulnerability and build resilience. This requires regulation and planning to manage the impacts of climate change and combat the vulnerabilities associated with weather phenomena. Social dynamics and adaptation processes in cities also reflect income inequalities, which, in turn, constitute one of the major obstacles to implementing an adaptation strategy. Lastly, the discussion on climate change adaptation must take account of impacts that occur outside the urban area. Climate change has a huge impact on food security, which affects cities both socially and in terms of income.
- When studying vulnerability to the impacts of climate change on an urban scale, it is essential to use a common conceptual framework and a methodology that allows comparisons between different cities.

E. Summary: downscaling of climate change models for Latin America

See table III.4.

F. Summary: impacts of climate change in Latin American cities

See table III.5.

TABLE III.4
LATIN AMERICA (SELECTED CITIES): DOWNSCALING OF CLIMATE CHANGE MODELS

Metropolitan area	Historical context	Characteristics of the models	Manifestations (temperature and rainfall)	Manifestations (extreme events)	Particular features
Buenos Aires	Rise in temperature and rainfall. Effects on the River Plate (tributaries, wind, sea level, precipitation).	PRECIS forced by HadAM3P. 50km approx. Daily data. Time periods: 2020-2029; 2050-2059; 2080-2089. A2 and B2.	Rise in temperature: 0.6°C to more than 2°C (minimum more than the maximum). Slight decrease in precipitation during the first time period, then an increase.	Increase in severe storms of greater intensity and length.	Sudestadas (south-easterlies).
Bogotá	Decrease in precipitation until 1950; after which it rose. Rise in temperature.	Statistical and dynamic downscaling (PRECIS) A2 and B2. Time period: 2070-2100.	Rise in average annual temperature of up to 4°C. Possible decrease in precipitation by up to 50%.	La Niña: extreme rains. El Niño: drought, water shortages.	Complex orography, difficult to represent on a 25km scale. (Cauca Valley is not represented in the model). ENSO.
Lima	Fewer cold days. Minimum temperature rose by an average of 0.30°C per decade, maximum temperature rose.10°C. Low precipitation. 1930-1950 greater rainfall than today.	Statistical and dynamic downscaling (PRECIS). Two time periods: 2050-2059 and 2090-2099.	2050-2059 slight increase in precipitation in the Rímac river basin. Temperature increase of 1°C; other models 2°C -3°C. Heat island effect.	La Niña: possible extreme rainfall. Tropicalization.	ENSO. Desert climate. Close to the mountains and the ocean.
Mexico City	Average temperature rises to 1.6°C more than the average in the twentieth century. Flooding and drought cycles in Mexico City Valley (between 1450-1900, 136 major droughts have been recorded).	Modelling (Mexico state and Federal District), in conjunction with the Centre for Atmosphere Sciences (UNAM). Grid 5kmx5km 10kmx10km. Three time horizons: 2030, 2050 and 2080.	Up to 20% decrease in precipitation. Temperature rise of up to 4°C. Heat island effect.	More droughts. More heat waves. Short periods of intense rainfall.	

Santiago		CMIT3. Daily for the metropolitan region according to statistical downscaling A2 and B1 time period: 2045-2065.	Significant rise in maximum temperature (up to 2.5°C). Inconsistent and small precipitation levels. But: Decrease in frequency of rainy days and drop in water levels in the rivers.	Fewer days with heavy rainfall, but rise in heavy rainfall with high temperatures. Sharp increase in days with a high temperature of > 30°C.	Topography and existing climate (seasonal).
São Paulo	Rise in temperature. Rise in precipitation and heavy rains in the summer. Dry winters.	Eta-CPTEC 40 km (improved from 20 km). Three time periods: 2030-40, 2050-60 and 2080-90.	Rise in temperature. Rise in precipitation and heavy rainfall. End of the century: more droughts. Heat island effect.	Instances of heavy rainfall (> 100mm, >5 days) Impacts of mudslides. Floods (50mm).	Tietê river basin (urbanized).

Source: Prepared by the authors on the basis of information presented by workshop participants.

TABLE III.5
LATIN AMERICA (SELECTED CITIES): IMPACTS OF CLIMATE CHANGE

Metropolitan area	Effects/Outputs	Impacts/Outcomes	Vulnerability	Social/Environmental context
Buenos Aires	Floods.	Interruption of daily life. Damage and loss of homes and infrastructure. Economic Losses. Health.	Vulnerability associated with flood risk and water contamination.	Concentration of vulnerable neighbourhoods in the south (Riachuelo). Social/spatial segregation.
Bogotá	Sudden temperature increases. Floods. Mudslides.	Damage and loss of homes and highway infrastructure. Fires: damage to ecosystems and houses. Heat island effect.		Income difference is a formidable obstacle for adaptation.
Lima	Mudslides. Floods.	Destruction of major housing and highway infrastructure.	No rainwater drainage systems. Flat roofs. Populations living in hazard zones.	Large urban sprawl. Rapid urban expansion.
Mexico City	Water shortage. Floods (intense precipitation). Contamination.	Housing destroyed. Health problems.	Deficient infrastructure. Low-income sectors not necessarily more exposed.	History of environmental change (increase in vulnerability). Lack of water-related infrastructure.
Santiago	Floods. Water shortages.	Problems with energy and water supply.	Exposure of different socioeconomic groups to risk (floods, thermal stress, water shortages).	Wide-ranging segregation. Downpours.
São Paulo	Mudslides. Floods.	Loss and damage to housing and infrastructure. Floods create and spread strains of leptospirosis (rats).	Precarious housing located on river banks Lack of areas to retain/collect water. Protection infrastructure.	Segregation and (illegal) occupation of areas with high levels of exposure. Urban expansion. Verticalization.

Source: Prepared by the authors on the basis of information presented by workshop participants.

IV. Practical application and governance of climate change in megacities of Latin America

Given climate change and its impact on cities, the need for short-term action through urban policy plans is evident. The reigning national focus in connection with issues such as clean development mechanisms makes it important to bring climate change policy down to an urban-scale and promote local action because the effects of climate change are experienced directly at that level. Despite the ongoing mitigation policies, it is not enough to prioritize mitigation at the national level without taking action to adapt to existing effects or to those expected for the future at the regional and local levels (Smit and Wendel, 2006; Tompkins and Adger, 2005; Krellenberg, 2012). For this reason, several authors have called for local adaptation plans to be designed (Mukeibir and Ziervogel, 2007; Penny and Wiedtz, 2007). In particular, according to Betsill and Bulkeley (2007), adaptation should include different administrative units of governance (such as cities, regions and countries), or networks between public and private actors across the different levels of social organization.

Responding to the main challenges of climate change necessarily includes the problem of creating suitable institutions for adaptation. This includes the regulatory framework as well as policy management, plans, and instruments at the various administrative levels. One of the central themes is that adaptation is not necessarily addressed as such, but can also emerge in the framework of urban development planning, which makes it possible to address the issue in integrated manner rather than an add-one. Furthermore, adaptation may be considered part of the "very nature of human development", as expressed by an expert participating in the Regional Learning Network.

"Processes of adaptation have taken place throughout history. We, humanity, see the signs in terms of the costs and environmental problems that we are facing and we adapt in response to those signs. I think adaptation is part of our nature and is what makes us more resilient."

The main issues that influence and sometimes hinder adaptation to climate change at the institutional level are presented below. This section will therefore discuss the following topics for each city:

- Existing policies and programmes to deal with climate change;
- Main issues addressed in existing policies;
- Integration of existing policies and plans that do not necessarily target climate change specifically and possible points of future integration;
- Institutional responsibilities in climate change;

- Financing and evaluation mechanisms for existing programmes and measures;
- Progress achieved and obstacles faced in the climate change adaptation process.

A. Climate change policy in Bogotá

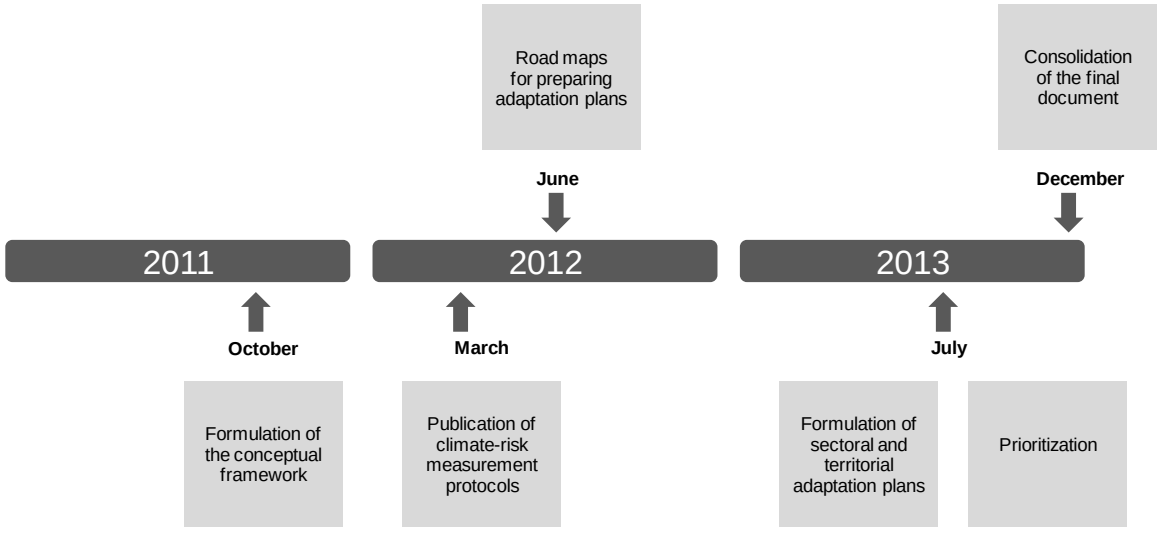
(a) Existing policies: background and scope

In view of the possible modifications and impacts that the climate change phenomenon would cause in Bogotá, the environmental authorities have set up different working groups. Climate change standards have been developed by the city council. The District Secretary of the Environment works with universities to address the impacts of climate change associated with air pollution and risk management, among other issues.

In Colombia, at the national level there has been a long tradition of discussion on climate change, and it was one of the first countries to ratify the Kyoto Protocol. To this day, broad information is available at the national level, and most actions in response to the impacts of climate change are developed at that level. The first national report was published in 2001, and a second one in 2010, involving more than 70 public and private institutions. Between 2006 and 2011, the national pilot project for climate change adaptation (INAP) was implemented with the participation of the following institutions: Acción Social, Conservación Internacional, the World Bank, GEF, IDEAM, INVEMAR, CORALINA, the National Health Institute, the Chingaza peasant community and the grassroots community of San Andrés.

Following the severe floods in 2011, and in light of the fact that floods and landslides have featured prominently in the country's history, a number of ministries have placed a high priority on risk reduction. The creation of a National Climate Change Adaptation Plan (PNACC) has been initiated; and its road maps, for both territorial and sectoral plans, were launched at the end of July 2012 in Bogotá (2012 National Plan; see figure IV.1 for the timeline for the development of PNACC). The objective of this plan is to reduce the vulnerability of the population and its livelihood.

FIGURE IV.1
COLOMBIA: TIMELINE OF THE NATIONAL CLIMATE CHANGE ADAPTATION PLAN



Source: Presentation by María Claudia García, Ministries of Environment, Housing, Territorial Development.

On the metropolitan scale, a Bogotá-Cundinamarca comprehensive regional climate change plan (PRICC Capital Region) is being set up in four phases: (i) development of stakeholder capacity to contribute to the new approaches to development that respond to and make it possible to manage the risks associated with climate change in the Capital Region; (ii) creation of a regional climate profile and identification of alternatives; (iii) the formulation of PRICC to incorporate climate change responses into the path of territorial development; and (iv) the management of strategic knowledge and communication in the Capital Region and nationwide.

(b) Key issues

As previously noted, adaptive responses to climate change have been made specifically at the national level. Nonetheless, some urban-regional actions in Bogotá essentially replicate the national plan. The focus includes the following: more sustainable agriculture in the areas surrounding Bogotá; the search for more efficient ways of using water; and the reduction of the risk of precarious buildings (such as in Ciudad Bolívar), which includes relocating people living in hazard-prone areas. These actions are accompanied with measures to raise public awareness on climate change issues that, until now, have not been widely disseminated. Specific measures at the local level have been added in the health sector.

(c) Integration of existing plans and policies

Climate change management is interlaced with environment management and risk management. These are integrated and complemented in the country through land use and development planning, as clearly shown by the fact that the PNACC process is led by the National Planning Department, with active support from all territories and all sectors of production.

Policies aimed at improving conditions for the low-income population made progress in the last decade, especially after 2007, with the creation of the Housing Secretariat. This secretariat works in partnership with other agencies such as the Department of Prevention and Emergency Response (DPAE), which is setting benchmark parameters that other entities can use to improve neighbourhood infrastructure and housing. In this sense, land management centred on risk mapping is a factor of both coordination and power; for some actions may be of value to the population and are subject to what is considered correct or incorrect from a risk management perspective.

At the national level, the following sectoral initiatives could in the future be integrated with adaptation issues:

- Energy: the 2006-2025 National Energy Plan;
- Forestry: Forest Policy (DNP, 1996), the Green Plan (DNP and MMA, 1998), and the National Forestry Development Plan (DNP and others, 2000);
- Agriculture: Interministerial Environment Agenda between the Ministry of Environment, Housing and Territorial Development (MAVDT), the Ministry of Agriculture and Rural Development (MADR), and the Strategic Environmental Plan for the Agricultural Sector (PEASA).

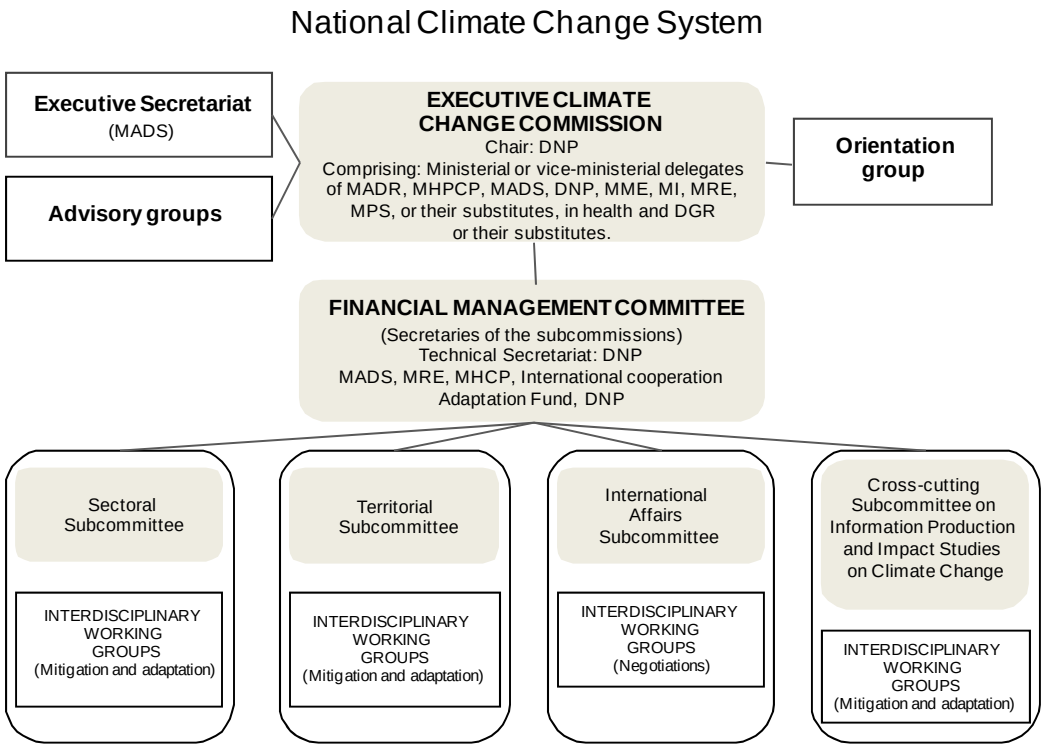
In this context, it is important to highlight the fact that the existence of natural disasters such as floods and landslides, and a policy to deal with them, makes it much easier to develop adaptive policy than in other cities, since risk management is closely linked with climate change adaptation policy.

(d) Institutional responsibilities

In terms of institutional responsibilities in Colombia, decision-making and the development of guidelines is led by the National Planning Department (DNP); this agency is also proposing a national climate change adaptation plan (PNACC). Furthermore, the National Climate Change System has been approved in the National Economic and Social Policy Council (CONPES). This group includes

an Executive Climate Change Commission, composed of ministers and vice-ministers, and supported by a Financial Management Committee. The Financial Management Committee consists of the Sectoral Subcommittee; the Territorial Subcommittee; the International Affairs Subcommittee; and the Cross-cutting Subcommittee on Information Production and Impact Studies on Climate Change (see figure IV.2). In addition, an Adaptation Fund (Restoration, Construction, and Reconstruction) has been established.

FIGURE IV.2
COLOMBIA: INSTITUTIONS INVOLVED IN THE NATIONAL CLIMATE CHANGE SYSTEM



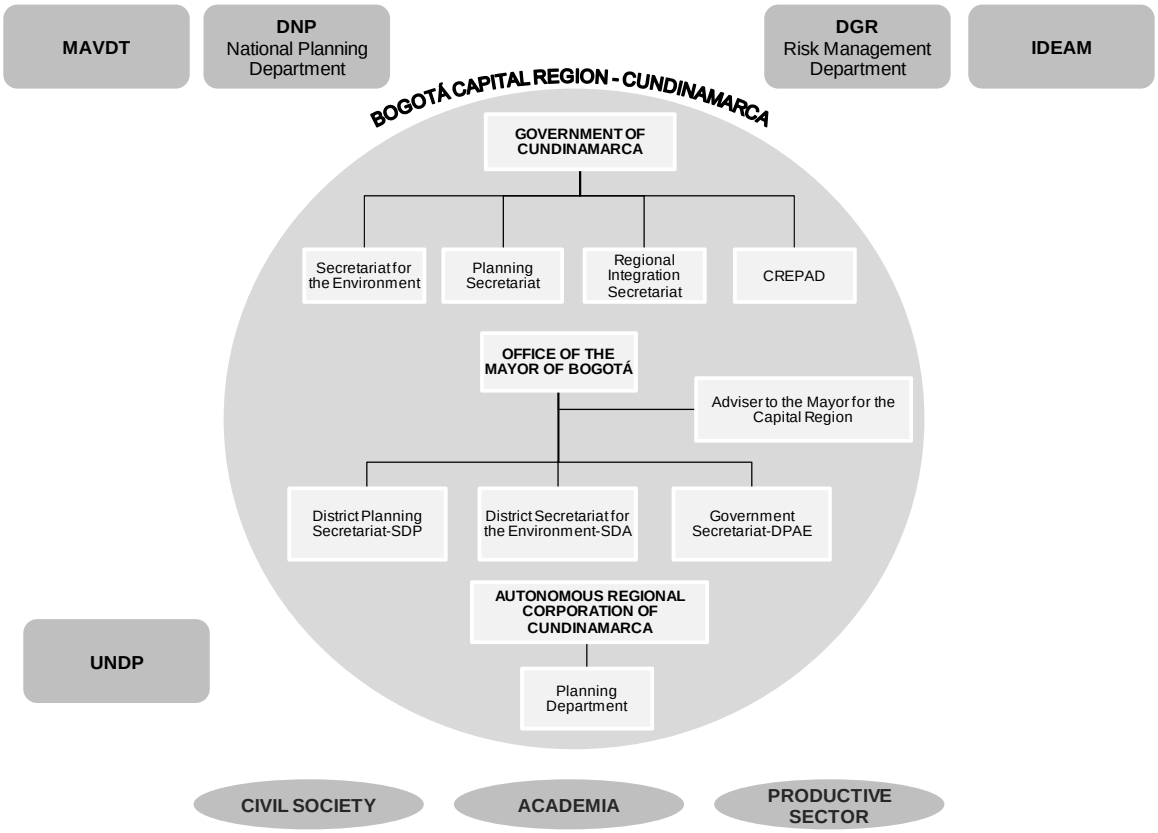
Source: Presentation by María Claudia García, on the basis of data from DNP and MAVDT.

At the national level, there is a committee formed by the sector ministries which cooperate with a technical secretariat formed by the National Department of Planning and the Ministry of the Environment and Sustainable Development. The issue of climate change comes under the purview of this Ministry, which will set up a climate change unit. At an urban regional level in Bogotá, there is the District Secretariat of the Environment, which coordinates the discussion on climate change for the city. Looking beyond the capital district, the Bogotá Comprehensive Regional Climate Change Plan includes the entire Metropolitan Region, and comes under the responsibility of the Ministry of the Environment. Within the scope of the district plan, a partnership with the department of the Cundinamarca Region has been created, forming an inter-institutional platform for climate change, and thus strengthening an integrated perspective of the Metropolitan Region of Bogotá (see Pacheco 2009: 24 and figure IV.3).

Nevertheless, a map of the different actors of Bogotá suggests that adaptation capacity is not considered in depth at the city level. Reference can be made to a "polyphony" of institutions, and the question of overlapping powers. The fact that adaptation policies and institutions are a national priority must be highlighted; however, there are also initiatives for decentralization, on which there are

various opinions. Several district institutions play a role in relation to adaptation, such as the District Secretariat for the Environment (SDA), the District Housing Secretariat (SDH), the District Education Secretariat (SDE), the Social Integration Secretariat (SDISl) and the Emergency Prevention and Response Department (DPAE).

FIGURE IV.3
BOGOTÁ CAPITAL REGION, CUNDINAMARCA: STAKEHOLDERS IN CLIMATE CHANGE ADAPTATION AND LAND-USE MANAGEMENT



Source: Pacheco 2009: 25.
Abbreviations: MAVDT = Ministry of Environment, Housing and Territorial Development; DNP = National Planning Department; DGR = General Risk Department; IDEAM = Institute of Hydrology, Meteorology and Environmental Studies; UNDP = United Nations Development Program; CREPAD = Regional Disaster Prevention and Response Committee.

(e) Financing and evaluation of existing measures

In Colombia, cost-benefit evaluations have been made of the adaptation measures that were developed on the basis of the Integrated National Adaptation Project (INAP). The experience in Bogotá is evidence that INAP has the same level of complexity as can be found in a cost-benefit analysis of other environmental projects. According to INAP, an *ex ante* and *ex post* evaluation should be made of the costs and benefits in an adaptation plan, taking care to prevent the cost-benefit calculation becoming more complex than the preparation of the plan itself. In Bogotá, the UNDP and World Bank methodology of incremental costs is applied to the adaptation measures.

In financial terms the District Programme of Action on Climate Change has the support of private businesses and the Clinton Foundation, and also from the following national entities: the Ministry of Environment, Housing and Territorial Development (MAVDT); the National Planning Department (DNP); the Institute of Hydrology, Meteorology, and Environmental Studies (IDEAM); and from the United Nations Centre for Regional Development (UNCRD).

(f) Obstacles encountered and progress achieved

In Bogotá, although there are various factors that favour adaptation, improving coordination and preparing an integrated plan between the different agencies remains a major challenge that the city must take on in the future. Disaster risk management possibly remains one of the most successful experiences in all of Latin America thanks to advances in the institutional response capacity, the geo-referenced diagnosis of threats and progress on inter-agency management by the headquarters of the Disaster Prevention and Response Fund (FOPAE). This institution coordinates the actions of the Emergency Prevention and Response Department (DPAE) in Bogotá, and that of the other district entities, as well as implementing community risk management. All the municipalities now have a disaster prevention and response office; and the District Committee for Disaster Prevention and Response in Bogotá was created with a monitoring network. At the national level, a permanent weather forecasting service was set up in collaboration with the National Oceanic and Atmospheric Administration (NOAA) of the United States. Nonetheless, one important element that is still missing concerns vulnerability management: the causes of social vulnerability when facing climate change continue to pose a major challenge for the Colombian capital.

For the city of Bogotá, the inclusion of climate change adaptation in the agendas of the different sectors of the regional and national government has been achieved. In general, institutional and financial capacity has been built. Considering the situation in other capitals in Latin America, it should be noted that in Colombia collaboration on climate change has been established between the capital district and the Cundinamarca Region, which promotes the development of a metropolitan perspective that bridges administrative boundaries. Nevertheless, the inter-agency coordination required for the process of adaptation still poses certain obstacles for Bogotá, both in the integration of adaptation in environmental management, and in the continuity of the financing when faced with political changes.

B. Climate change policy in Buenos Aires

(a) Existing policies: background and scope

In Buenos Aires, decision-making at the metropolitan level is highly complex due to administrative and political divisions. In the Metropolitan Area of Buenos Aires, there are three jurisdictions: the national level; the Province of Buenos Aires, which comprises the greater urbanized area or conurbation; and the Autonomous City of Buenos Aires —the Federal Capital.

In terms of actions to confront climate change, the National Climate Change Strategy (ENCC) has been in development at the national level since 2010. The first stage of the ENCC came to an end in September of 2011, and, in November of that year, plans were drawn up for the second stage with the aim of defining indicators and goals for the proposed actions. Since 2010, the Governmental Climate Change Committee, formed by all national Secretaries of State and with representation by the provincial environment ministries through the Federal Environment Council (COFEMA), has been in operation. The ministers set clear objectives and directives for adaptation action. The general objective of the strategy is to identify, promote and implement climate change adaptation measures, taking account of the impacts caused by climatic variability for particularly vulnerable populations, productive activities and ecosystems.

At the national level, the Ministry of Federal Planning, the Ministry of the Interior, and the Department of Environment work in conjunction. They have produced a handbook on the impacts of climate change, its prospects and a methodology that would make it possible to implement specific policies and measures for the province of Buenos Aires.

At the provincial level, six years ago a working group on climate change was organized, and a provincial strategy was generated to mitigate and adapt to climate change. It included members of civil society and NGOs working in a participatory social process, ranging from the local to the international level, and working directly with the municipalities. The Provincial Climate Change Council was also formed, which includes all provincial ministries, and started to operate in the different sectors in an integrated manner. Also, there is a project by the Federal Environment Council (COFEMA), which is setting up a Climate Change Commission. As this commission is progressing much faster than the work at the national level, the province of Buenos Aires has already identified the carbon footprint of its export products, for example.

On a local scale, the Autonomous City of Buenos Aires has defined the Buenos Aires Plan of Action 2030, heavily focused on mitigation given the administration's tendency to implement large infrastructure projects. The Climate Change Adaptation and Mitigation Act of 1 September 2011 (Act 3,871 [http://www.cedom.gov.ar/es/legislacion/normas/leyes/ley 3871.html]) was also focused on a local scale and adopted a more progressive plan. It created a Plan for Adaptation and Mitigation for Buenos Aires, explicitly including the issue of vulnerability, and calling for collaboration between the federal capital and the province of Buenos Aires.

During the workshop discussion, the importance of attempting to maintain direct links at a technical level between the city of Buenos Aires and COFEMA was emphasized. Researchers play an important role in this process, as they often facilitate the dialogue to generate a neutral and intermediate space. COFEMA is a central organization where provinces and municipalities meet, and today it functions well in terms of strengthening capacities and disseminating ideas. There is a very direct dialogue, but at the level of the Province of Buenos Aires, individuals are needed to promote the defined policies and projects.

(b) Key issues

Institutional climate change policy at the metropolitan level, such as the Buenos Aires Plan of Action 2030, is based on mitigation measures such as improving infrastructure, switching to low-energy light bulbs, small-scale tree-planting, and proposing a programme of energy efficiency in public buildings; and on measures to improve and prioritize pedestrian, bicycle, and public transportation. The few adaptation measures that exist are at the sector level (infrastructure, biodiversity, energy), and prioritize topics such as management, studies, and strengthening the early warning system for floods.

The topic of vulnerability is included in the National Action Plan and the City of Buenos Aires Land Management Plan, and will also play a role in the new Adaptation and Mitigation Plan for the City of Buenos Aires. According to the Climate Change Adaptation and Mitigation Act (Act No. 3,871), the plan will largely be devoted to adaptation, incorporating the concept of future climatic risks, along with risk monitoring and management. It is important that the new mitigation and adaptation policies and measures are integrated into the key planning processes. The new plan will thus evaluate the design strength of metropolitan infrastructures and long-term investments, focusing particularly on sociodemographic and transportation projections.

(c) Integration of existing plans and policies

To promote adaptation in the case of Buenos Aires, a persistent problem concerns different sectoral approaches, and often the lack of knowledge about climate change and its local effects. In general, rather than new studies, the need is for better availability of information on the correct

geographical scale and in an appropriate language for various political, administrative and general public actors.

The Reconquista River Basin Committee (COMIREC) can play an important role in adaptation, including flood prevention and potable water supply. The committee was founded in 2009 and encompasses 18 municipalities throughout the province of Buenos Aires. It has links with the Ministry of Infrastructure which is responsible for integrated management of water resources and the organization and planning of the river basin. There are other potential links as regards mitigation, such as the National Alternative Energy and Fuels programme and (Provision 166/01 of August 2001).

(d) Institutional responsibilities

The institutional framework for establishing the link between existing institutions and programmes and those dedicated to climate change adaptation in the Metropolitan Region of Buenos Aires is primarily the government's climate change committee, and secondarily, the Provincial Council on climate change. There is also a Provincial Emergency Council, and other entities. The council organizes round table discussions, and serves as a platform for links between sectors and decision makers. The key feature of this approach is that it is a bottom-up process.

There is a need for improved communication between different administrative levels, and promotion of dialogue between stakeholders. The Environmental Protection Agency of the Autonomous City of Buenos Aires (which is part of the Ministry of Environment) could take a decisive role in promoting cooperation between the different levels of the administration. Until now, the lack of coordination between different sectors and government levels, as well as the lack of a regulatory framework for the issue of climate change, has implications for adaptation in terms of risk management and the reduction of vulnerability. There is no land act that controls building in flood-prone areas; and land-use regulations are yet to be enshrined in law, under the jurisdiction of the Autonomous City of Buenos Aires or the province of Buenos Aires, or in a national context for the band of land along the River Plate bank.

The creation of the Climate Change Action Plan of the City of Buenos Aires defined two domains of work and coordination: the inter-agency climate change team, and the External Advisory Council, both led by the Environmental Protection Agency of the Ministry of the Environment and Public Spaces, with the objective of developing policies that allow for the evaluation and implementation of practical climate change adaptation and mitigation measures.

(e) Financing and evaluation of existing measures

For Buenos Aires, future progress in the implementation of adaptation measures is expected, with a focus on tax incentives for good practices, rather than fines and penalties. There is an interest on the part of the municipalities to charge taxes. The experience with incentives in Buenos Aires is still new at a metropolitan level, although at a national level resources are being channelled into incentives. There is an agreement between the Ministry of Planning, the Ministry of Interior, and the Secretariat of the Environment regarding the issue of risk and disaster management, which is functioning well and has a great deal of support.

Informal evaluations are made by the press and civil entities. The measures are included in the third communication which also analysed the second and evaluated implementation of the recommendations.

(f) Obstacles encountered and progress achieved

In Buenos Aires, general public-awareness has been achieved, better stewardship of water resources has been encouraged, and agricultural production technologies have been modified to address the problem of desertification. An inventory of glaciers, the Native Forests Act, and legislation on coastal management have also been produced created. At an institutional level, a

governmental climate change committee has been formed, along with three specific councils that operate in this context (Pro-Emergency Council, Water Council, and Federal Environment Council).

In terms of obstacles, the Metropolitan Region of Buenos Aires does not have an adequate monitoring infrastructure or public network of online information. In general the costs are a major obstacle to the implementation of adaptation and mitigation measures alike. Added to this are time constraints, and interdisciplinary, inter-agency, and inter-jurisdictional challenges for the work of the institutions. Mechanisms need to be created for adjusting existing plans, and responsibilities need to be defined in decision-making with respect to climate change adaptation. It is a challenge to find the balance between development and conservation, from the standpoint of urban sustainable development.

C. Climate change policy in Mexico City

(a) Existing policies: background and scope

In Mexico, at the **local level** (Federal District) the Local Climate Change Strategy was developed in 2006, which laid down general guidelines. In 2008, the Climate Action programme (PACC) was introduced, with concrete goals and deadlines to be met for annual progress reports. In June 2011, the Act on Climate Change Mitigation and Adaptation and Sustainable Development for the Federal District was adopted. The whole process of finding solutions to climate change involves different stakeholders in civil society and in government, and presents clear goals for the reduction of carbon dioxide and the creation of a climate change adaptation programme. The specific goals include a target for the development and implementation of a climate change adaptation programme to be in place and functioning by 2012.

Adaptation –as opposed to mitigation– is a process in which one can define projects with goals and clear timelines. For this, institutionalization is very important, which is why the Inter-agency Climate Change Commission was set up. The members of the commission include thirty-six offices of the Federal District government, all of the secretariats and other actors, such as entities responsible for water management. There are plans to create a subcommittee on adaptation within this commission, with the aim of establishing an inter-sectoral adaptation policy.

In this context, it is important to note that only 8 million inhabitants of the Metropolitan Region of Mexico City live in the Federal District, while the remaining 12 million live in the state of Mexico, where no policy progress on climate change mitigation and adaptation has been made. This results in a complex urban policy, since for administrative and political reasons, regional cooperation is difficult in almost all aspects of urban policy.

At the **national level**, the National Climate Change Strategy (ENACC) was defined in 2008, aiming mainly at reducing greenhouse gases. In other words, there is a specific climate change programme —an inter-secretarial planning instrument at the top-level of the federal civil administration that focuses on mitigation. There are very specific targets, but the strategy also includes softer targets such as conducting studies. Support has also been provided for the implementation of climate change plans in all states, apart from the Federal District. With respect to adaptation, a road map for actions is being developed under the auspices of the National Low-Emissions and Climate Resilience Growth Strategy, proposed by the Office of the President. It is also being promoted by the Working Group for Adaptation under the Inter-agency Climate Change Commission. Furthermore, there are many studies being done at a national level, such as those preparing abatement curves.

In terms of mitigation, Mexico voluntarily presented a GHG reduction target in Copenhagen, which was ratified in Cancun: to reduce emissions by 30% in 2020 with respect to a baseline (BAU) with international support, in addition to the “aspirational” long-term goal (2050) of reducing emissions by 50% with respect to the 2000 level. This voluntary commitment is included in the new General Climate Change Act, published on 6 June 2012.

The SEMARNAT (Secretariat of Environment and Natural Resources) fosters the ability to develop climate change strategies in different states, along with diagnostic studies and scenarios, and to propose concrete measures for mitigation and adaptation.

It should be noted that ENACC is a strategy and not a plan, since it does not have clearly defined timelines, quantifiable goals, or defined responsibilities. This has to do with upcoming elections as well as government timelines, which led to an effort to separate the strategy from political cycles as far as possible. However, ENACC constituted an important base for the creation of the nationwide Special Climate Change Programme (PECC) 2008-2012. In terms of adaptation, this programme proposes three phases of action: (i) a vulnerability analysis; (ii) economic evaluation of measures; and (iii) strengthening strategic adaptation capabilities and consolidation (see PECC, updated version 2009).

Mexican experts highlighted that it is the scale and spatial limit of the Climate Change Action Programme (PACC) that make it difficult, given the administrative features of the metropolitan area. There is little growth in the central area of the city and little current real estate development, yet there is a great deal of growth on the outskirts of the city, especially in the state of Mexico. One problematic issue is that the PACC has not considered long-term urban planning, because in 2008 when the plan was published, the political situation did not permit this. The next PACC, to be launched in 2012, was expected to include long-term urban planning as one of the issues for the future.

(b) Key issues

The thematic focus of adaptation policies in Mexico mainly addresses the impacts on the agricultural sector, on biodiversity, and on public health. It emphasizes the impact that climate change can have on the population in vulnerable regions, from the standpoint of economic effects. Accordingly, “mini-Stern” economic studies have been done for each of the 16 delegations of the Federal District. Even in the most optimistic scenarios, the economic impacts of climate change are serious. The greatest impacts are found in low-income areas; in particular, flooding in the east of the city, which could result from future increases in rainstorms which, coincide with the poverty map. Furthermore, temperatures continue to rise, partly owing to urban growth and partly because of climate change.

(c) Integration of existing plans and policies

At the national level, many of the existing measures to confront climate change are not called “adaptation measures” by the entities that execute them. These measures are developed independently of climate change policies, and benefit the country's development in general or aim to reduce risk and vulnerability.

Particularly relevant to the proposed definition of adaptation is the collaboration of members of the working group on adaptation (GT-Adapt) and other public agencies (including the Legislature) with state governments, academia, the private sector, NGOs and aid agencies. Nonetheless, it is very difficult to implement a climate change adaptation policy if financial resources are scarce, because resources have to be prioritized, for example, to deal with diseases or to protect particular species of animals, or else they may be designated to support tourism infrastructure, a very important economic sector. Under these conditions, the integration of all relevant ministries, especially the Ministry of Finance, is very important.

(d) Institutional responsibilities

With respect to the different institutions involved with climate change in Mexico City, a number of issues should be highlighted:

- When the development of PACC began in 2006, the main question was how the process could be undertaken. Participation workshops were organized, and from the outset, all sectors were invited: academics, NGO’s, businesses, union leaders, and, very importantly,

city officials. The incorporation of officials from the outset created a very enriching experience, particularly in terms of international experience. From the point of view of the experts, the outcome was a highly valuable product, based on social and political consensus.

- Political leadership permeates the entire structure of the Federal District government: the Mayor of the city in this case was convinced of the issue of climate change and immediately adopted the PACC. However, this did not guarantee that the project would go well, or that the necessary resources would be available.
- To resolve some problems and weaknesses in the implementation of the plan, the Inter-agency Climate Change Commission was created at the Federal District level, in which all 36 secretariats and offices in the city participated. Presiding over the Commission is the head of the Federal District government. The commission plays a significant role in responding to the need for inter-agency coordination, in addition to incorporating the notion that adaptation policies must stretch beyond electoral periods.
- The creation of the Federal District Climate Change Act (which came into effect on 16 July 2011) led to the establishment of the Inter-agency Commission which is responsible for the climate change policy in its entirety (development, coordination and monitoring), and has legal responsibilities. The law also defines the existence of an adaptation fund with fiscal resources from the Mexico City government. Mexico thus has a very significant legal framework that is lacking in all other major cities.

In sum, Mexico has a well-developed institutional framework, at least as far as the Federal District is concerned. A climate change plan has been developed, which prioritizes mitigation, but an adaptation strategy, based on sound information, is needed. There is still a lack of information on modelling the implications of climate change on the scale of the metropolitan region, resulting in a shortage of knowledge that hinders the development of specific adaptation measures.

(e) Financing and evaluation of existing measures

The costs of the measures of adaptation are covered by the budgets of each government office in the Federal District, based on earmarked fiscal resources. Sources of finance employed at the city level include the Public Environment Fund, the mixed funds of ICyT/CONACYT, the World Bank, and the Mario Molina Centre. At the national level, international funds are used, including from the World Bank, the Government of Norway, the Convention of the United Nations Framework on Climate Change (UNFCCC), the Adaptation Fund and the Green Fund. For the future it would be important to build more fiscal resources for adaptation. Although the experience in Mexico is positive as a whole, there have been and currently are significant obstacles, especially in the continuing absence of legislations. Despite having defined measures, costs, responsibilities and evaluations, funding was not clearly defined, and the issue of a lack of resources was absolutely crucial. The law currently allows for the creation of an adaptation fund, which is about to happen; and the Federal District Assembly will decide on resource allocation. Nonetheless, the law refers only to the Federal District and not the metropolitan area as a whole.

There is hope that after the 2012 presidential elections, there will be a return to a metropolitan policy, as was the case with environmental policy on air quality, ProAire. In that connection, the Government of the Federal District, the Government of the state of Mexico, and the Federal Government work together through the Metropolitan Environmental Commission.

Once a year, the 24 adaptation measures included in the Climate Action Programme of the Federal District are evaluated, along with all the measures included in both cost-benefit and socioeconomic terms. This evaluation and the flow of information have nevertheless been particularly difficult. While a specific “project by project” evaluation methodology is being developed for adaptation in cooperation with the virtual centre, mitigation matters are much more complex. In the evaluation of the measures for reducing greenhouse gases, for example, the fact that many institutions

are involved makes the process of identifying truly useful information very complex. Once the information has been received, the internal calculation work begins. Here, the dilemma is in deciding what methodology to apply. According to Mexican experts, evaluations such as those performed by project for the Clean Development Mechanism Project would be important; but they are difficult, time-consuming and costly. For this reason, the Federal District decided to apply an IPCC emissions inventory methodology of to evaluate the projects, which was not designed for this purpose.

(f) Obstacles encountered and progress achieved

The most important breakthrough for Mexico City is the launch of the process of mainstreaming climate change adaptation in the Federal District government's programmes and daily activities. In this way, climate change adaptation is not seen as an isolated project, but as a process in which all of society should be involved.

As in other cities, the financing and prioritization of measures are the main obstacles in Mexico City. Although various measures have been developed, there is a lack of capacity in the different sectors and levels of government, which makes adequate implementation difficult. Coordination and leadership are needed, language must be standardized and adaptation strategies need to be made compatible with all administrative departments.

With respect to flood hazards, there is an early warning system in the Federal District that did not operate in the past. This is particularly important given the collapse of drainage infrastructure during heavy rainfall events, aggravated by the subsidence of the city, which affects the water and drainage systems. Despite the fact that water is an urgent issue, it does not appear in the Federal District's Climate Action programme. Given its urgency, water issues acutely need to be integrated into the adaptation strategy.

The authorities of the Federal District of Mexico have a climate action programme (SMA, 2008) in place; they have developed a vision and a sophisticated definition of climate change; and they have strategies, organizations and institutions to deal with it. As a result, they have been able to localize a global issue, precisely because they have linked it to existing issues that are vital for the government's local agenda. National scientific groups (such as the Mario Molina Centre) and international organizations, such as the International Council for Local Environmental Initiatives (ICLEI) have played a key role in launching this policy agenda and in the learning process that is inherent to it (Romero Lankao, 2007).

This influence, however, has not been sufficient to promote strategies and effective policy actions, owing to various institutional factors. In its dual role, political and economic, the city has existed for almost a century with contradictory processes of centralized federal government control, and institutional fragmentation both in local structures of government and in social participation. There is a disparity between the fiscal capacity of the federal government, even in the Federal District, and that of the states and municipalities in the metropolitan area of Mexico City. The disparity gives rise to a paradox: more responsibilities are delegated to local authorities, but they lack the resources to implement their policies effectively. The authorities lack a culture of cooperation and a shared vision on a metropolitan scale. This may be due to the differences in the federal, state, and local election systems, as the entities involved (the Federal District and the state of Mexico) are governed by representatives from different political parties. Government agencies lack financial and human resources, decision-making powers, and other institutional elements needed to manage this policy issue effectively. Characteristics of the legal regime, such as the administrative mechanisms for compliance with environmental regulations, and negotiations between stakeholders, further weaken social participation.

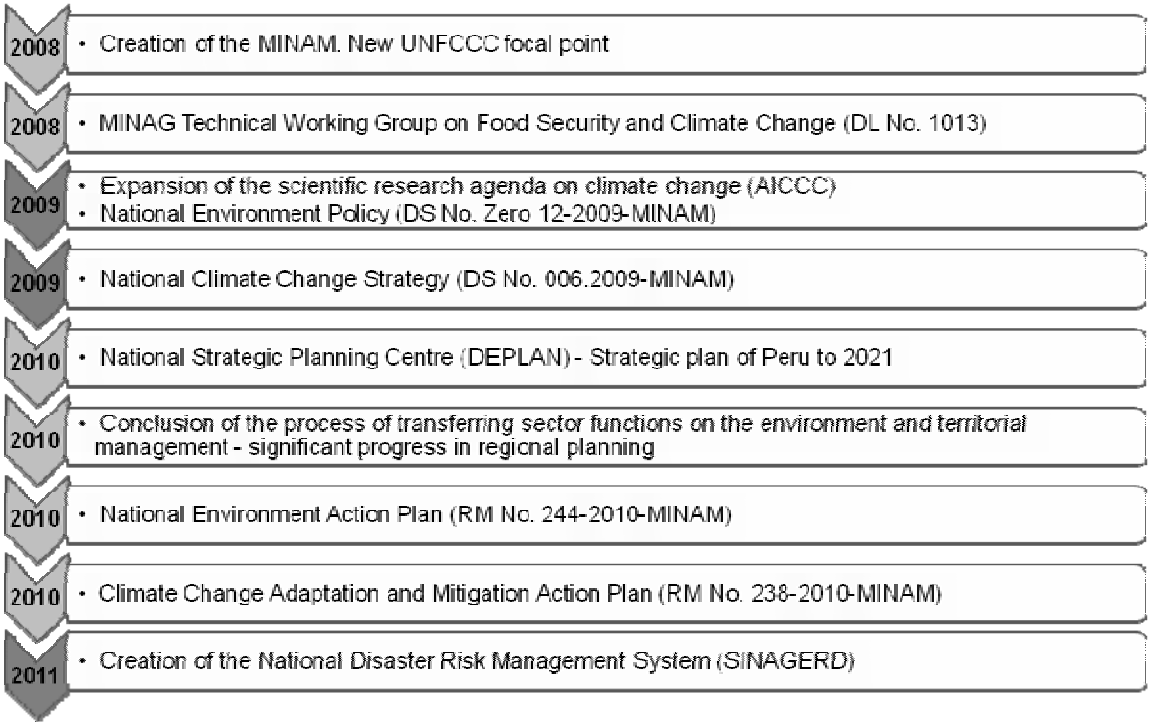
D. Climate change policy in Lima

(a) Existing policies: background and scope

The starting point in the Peruvian capital in terms of adaptive policy responses to climate change is understanding the term "adaptation" as reducing vulnerability. This is because Lima is subject to threats such as flooding and droughts, which are not expected to ease in the future. Consequently, a first step in taking action to address climate change was a diagnosis of the vulnerability of Peru, which began in 2009. This assessment, prepared by the Ministry of Environment, is cross-referenced with data from the Ministry of Housing, to identify the vulnerability of Peruvian cities to climate change with a view to proposing adaptation actions. This includes an assessment of exposure to the effects of climate change, a guide to reducing the fragility of structures, and initiatives to increase response and adaptation capacity.

The institutional policy framework that guides existing actions has been promoted by the Ministry of Environment (MINAM), which is responsible for the National Environmental Action Plan that gives rise to the National Climate Change Strategy (ENCC), also a MINAM responsibility. Figure IV.4 summarizes the chronology of these events. ENCC was drawn up in 2003, and revised in 2009.

FIGURE IV.4
PERU: TIMELINE OF CLIMATE CHANGE POLICIES AND PLANS, MINISTRY OF ENVIRONMENT (MINAM)



Source: Presentation by Eden Atalaya Haro, Ministry of the Environment of Peru.

Regional and sectoral instruments are either still in process or have not yet got off the ground. The existing local, regional and sector action plans do not yet have a climate change focus. At the local level, in the case of metropolitan Lima, there is currently a metropolitan environment policy approved in September 2012, and a direct climate change strategy is being developed. Accordingly,

for the development of the Metropolitan Climate Change Strategy, a process to coordinate stakeholders has begun (Technical Committee for Risk Management, Intra-municipal Climate Change Committee, Eco-efficiency Committee MDL Committee). Furthermore, an action plan for climate change adaptation is currently in preparation.

(b) Key issues

Climate change adaptation is one of the seven central themes of the ENCC, although other policies also address adaptation indirectly. These include the mainstreaming of adaptation and mitigation in decision-making, capacity-building and public-awareness-raising processes.

The nationwide diagnostic study shows that threats or impacts generated and identified through the problem of climate change are: floods, heavy rainfall, landslides, avalanches, drought and frost. Nevertheless, the main focus and orientation of action is centred on the vulnerability of cities in terms of exposure, fragility and resilience. Environmental fragility in some areas of Peru is considered in terms of precipitation and temperature, in both cases resulting from increases and decreases.

The climate change adaptation action plan that is being formed will centre on six general topics: (i) land management; (ii) ecological and eco-urban infrastructure; (iii) integrated management of river basins and water conservation; (iv) climate risk management; (v) the Metropolitan Programme on Urban Agriculture and Food Security; and (vi) capacity-building, institutional strengthening and public policy improvement.

At a local level in the metropolitan area of Lima, the main concerns are water-related; firstly water resources available for normal human activities are declining (Lima is a desert city); and, secondly, increased precipitation (in the upper parts of the river basins or in the city), could cause landslides and flooding in a city that is underprepared for extremely heavy rainfall. Floods can foster diseases that were not common previously, such as dengue or malaria. In response to water concerns, scenarios have been developed for Lima in the research project “Lima Water,” working in a participatory manner based on hydrologic models and scenarios [http://www.lima-water.de].

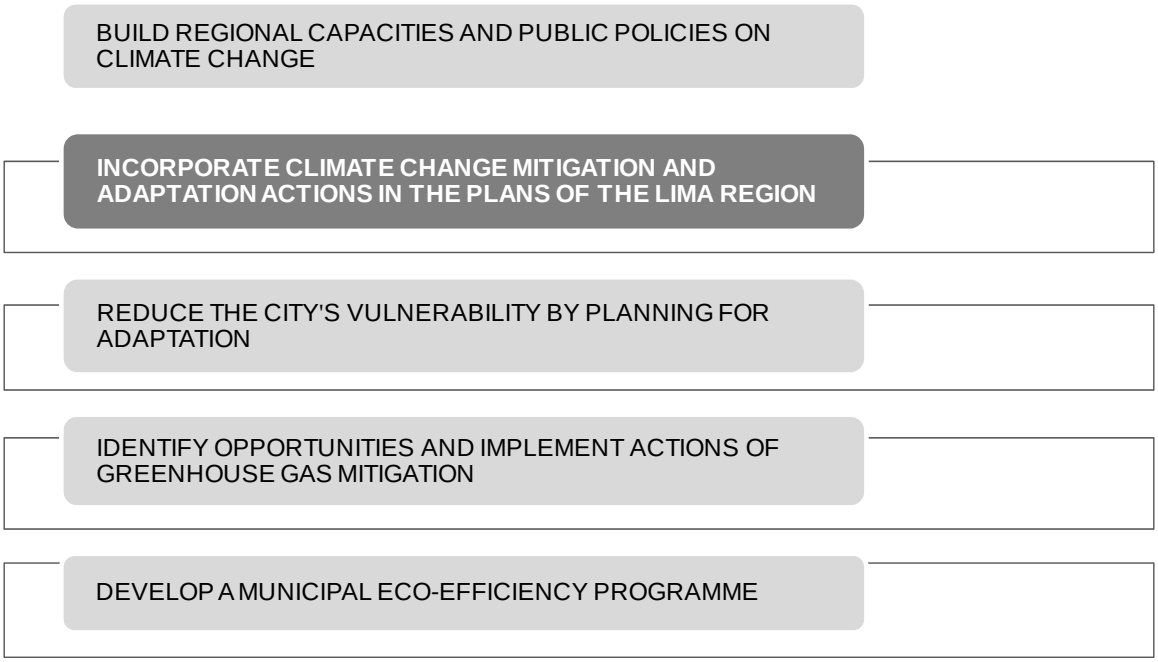
(c) Integration of existing plans and policies

Climate change programmes in Peru include the Regional Programme for the Social Management of Forest Ecosystems in Andean Bolivia, Ecuador and Peru (Ecobona and the Programme for Economic Development, Health, Food Security and Nutrition (DESSAN). There are also pre-existing environmental measures relevant to the issues of climate change adaptation that were not designed specifically for that purpose.

The key problem for the Peruvian capital in terms of climate change adaptation is the lack of management tools. This means that certain plans are outdated or non-existent, especially the following: the Land-Use Plan, the Environmental Plan, the Green Plan, and the Climate Change Strategy. Accordingly, Lima is now in the process of developing these plans, but is at a disadvantage because of a lack of progress in knowledge about adaptation. This could also be an advantage if Lima is able to update the plans, mainstreaming climate change adaptation challenges and concerns climate change adaptation in the various policies currently under development.

The existing Environmental Action Plan has the strategic objective of leading environmental management in Lima for climate change adaptation. One of the specific points of focus is to incorporate climate change mitigation and adaptation actions into the plans of the Metropolitan Region of Lima (see figure IV.5).

FIGURE IV.5
LIMA: STRATEGIC OBJECTIVES OF THE ENVIRONMENTAL ACTION PLAN



Source: Presentation by Ana Zucchetti, Servicios de Parques de Lima.

(d) Institutional responsibilities

At the national level, the Ministry of Environment (MINAM) is responsible for forming policies, plans and regulations for the management of climate change, all of which are performed in coordination with the various sectors involved through the National Climate Change Commission. No synergy has yet been achieved in this work.

Even though they do not have budgets earmarked specifically for adaptation measures, various sectors have nevertheless made some progress in this area. For example, the National Meteorology and Hydrology Service (SENAMHI) has promoted a process of information dissemination on climate change and strategies for dealing with climate change at the national level. The Ministry of Economy and Finance (MEF) has a climate change unit [http://www.mef.gob.pe], and the Ministry of Housing, Construction and Sanitation is developing a technical framework to promote sustainable construction.

This is what is in place at the moment, space for debate and dialogue, and strategy definition. As the climate change agenda is cross-cutting and influences many sectors, it requires a type of "superstructure" that should be functional and add value. This agenda has to have a coordinating role, enhancing and integrating sector policies, rather than owning the issue and constituting a separate parallel agenda.

For the city of Lima, one of the biggest challenges highlighted in the administrative-institutional area is its heterogeneity, reflected in differences in population, education, and economic, social and environmental factors, in addition to being governed by 43 elected district mayors and a provincial mayor.

Another key issue is the responsibility for budget management and for defining public expenditure priorities. Currently, under the Participatory Budget Act, each district submits a certain percentage of its investment budget for citizens to decide which projects should be undertaken. At the

provincial level there is a technical and strategic climate change group which has been working on the climate change adaptation strategy climate change adaptation.

In terms of risk management, local governments are responsible for managing natural disasters, but the national government plays an important role in risk mapping. Incentives are provided by the Ministry of Economy to those municipalities that meet the goals defined by the Ministry of Housing on this issue. The figures show that this has been a successful programme for the mapping of threats, vulnerabilities and risks.

(e) Financing and evaluation of existing measures

Although there is no evaluation of adaptation measures in Lima yet, a monitoring and evaluation system will be included in the climate change adaptation plan. There are evaluations of progress made in the implementing programmed actions, but not in terms of their effectiveness in confronting the impacts of climate change and adapting to them. Peru has had a positive experience with a very simple methodology for oversight of public investments, involving an ex ante evaluation of any type of public spending. When a project in any sector is at the pre-investment stage, the respective entities are responsible for verifying that a disaster risk analysis is performed. By law, all projects must include a risk item for adaptation to climate change risk.

In Lima at the moment, the creation of a green fund financed by automobile taxes is being evaluated; and a change in the structure of taxing drinking water through the Lima River Basins Trust Fund (AQUAFONDO) is also being considered. The problems of financing have been improved through partnerships with the central government and the relevant ministries; in the case of Peru, there are many projects related to climate change that have considerable financial resources. There are tax mechanisms such as carbon funds, or other mechanisms that accumulate permanent resources that can be targeted towards climate change. There is also international experience on innovative fiduciary instruments that could allow for the creation of more resources from each dollar deposited. For example, there is the Water Fund in Quito, which operates with the water tax, and an international contribution. In Bogotá a fund is currently in the incubation stage. To create an adequate fund for Lima, mechanisms outside the public budget should be considered to generate resources for investment in adaptation. These could even include the direct support from citizens, as they are now more environmentally aware than before. Of course, this does not replace the public budget, but rather complements it.

The National Climate Change Strategy has the financial support of the AVINA Foundation. At a national level, financing sources include entities such as MINAM, the National Service for Protected Natural Areas (SERNANP), USAID, the Japan International Cooperation Agency (JICA), the Swiss Agency for Development and Cooperation (COSUDE), the German Agency for Technical Cooperation (GIZ), the Inter-American Development Bank (IDB), the Global Environment Fund (GEF), the United Nations Development Programme (UNDP), the Moore Foundation, and private institutions.

(f) Obstacles encountered and progress achieved

The most significant challenges for the future in the adaptation of the city of Lima to climate change are the following:

- Land and city governance;
- The integration of land, housing, water, and risk management policies;
- The provision of reliable information for the design of priority projects;
- The calculation of costs and benefits of climate change strategies under different scenarios, and;
- The extra-jurisdictional integration of strategies with neighbouring regional governments, between sectors and between levels of government.

The main obstacle to the implementation of a climate change adaptation policy in the Peruvian cities is limited information on climate hazards and the associated vulnerabilities. There is a lack of a clear methodology and legal support, as well as a bias in approaches to climate change adaptation favouring rural areas. The Ministry of Housing is especially committed to this. There is a clear need to reduce the discrepancies that exist between environmental policies for adaptation to climate change and practices at the sectoral and local levels to promote the safety of the public and to secure public and private investment.

As metropolitan environmental policy in Lima includes adaptation to climate change, the issue has also managed to gain a place on the agendas of the national and regional governments, which is institutionalized in the Climate Change and Natural Resources Subdivision. A technical group focused on climate change is responsible for convening and organizing the stakeholders, which means there is now greater institutional capacity and a larger budget than previously.

As for specific issues, in Lima water is a particular problem, which is reflected in a variety of activities: measures to promote efficient use of water resources, the attempt to reconcile the Wastewater Master Plan with the Parks and Gardens Plan, and the construction of seawater desalination plants. In institutional terms, the Water Resources Council of Lima's three river basins was established, as well as a Lima river basins trust fund (AQUAFONDO). The design of a system of green areas and the ecological structure of the city of Lima is 70% complete and in terms of risk and environment, a vulnerability assessment has been carried out, and public awareness of the links between the environment and human health has been strengthened.

Limited financing and institutional capacities are the main obstacles to climate change adaptation in Lima. Individualized information on a micro/meso scale hinders decision-making. Another difficulty is the integration of measures on different scales, in many sectors, and involving a wide variety of actors. In particular, the fragmentation of responsibilities means that the control of human rights is out of the hands of the municipality, and a supply approach prevails over demand.

E. Climate change policy in Santiago

(a) Existing policies: background and scope

The National Climate Change Strategy was formed by the National Environmental Commission in 2006, and it provides the main public policy directives concerning climate change. The National Action Plan for Climate Change for the period 2008-2012 was prepared on this basis. Furthermore, with the new Environment Act (No. 20,417) and the creation of the Ministry for the Environment in 2010, the responsibility for public policy, programmes, and action plans has been transferred to the Ministry (Act No. 20,417, article 70 h). The same law also created the Office of Climate Change, specifically responsible for this issue at the ministerial level; and it presented the following directives based on the National Action Plan for Climate Change: GHG inventory; studies and national plans for mitigation; studies and national plans for adaptation; capacity building (training, dissemination, education and research); UNFCCC (international negotiation, national communications); and clean development mechanisms. In this manner, this organization coordinates and appoints other institutions responsible for each topic.

The National Climate Change Strategy has defined deadlines, distinguishing short-term actions (2008-2010) and mid-term ones (2010-2012); and it is focused on sectors that were defined as vulnerable as well as sectors that generate the vast majority of GHG emissions (mitigation). The strategy also recognizes the importance of having suitable institutions to address the topic, considering their current and future relevance. The action plan has also been designed to address the directives and goals of the National Climate Change Strategy. To this end, it considers directives and actions in three areas: adaptation to climate change impact, mitigation of greenhouse gas emissions, and the creation and

fostering of skills to tackle the problem in Chile. The plan has a sectoral structure, but the focus is not on the urban-regional domain. Currently, sectoral adaptation plans at the national level are being developed.

Given the factors discussed above, measures or other concrete actions at the urban-regional level were not available. That was the starting point for working on the CAS project, the creation of a regional climate change adaptation plan jointly with the Regional Government, the Regional Environment Department (SEREMI) and a wide range of other actors. For further information, see box V.5 and [http://www.climate-adaptation-santiago.ufz.de]. This means that the regional metropolitan government did not have a climate change adaptation plan before this was handed over by the CAS project in November 2012. Furthermore, the subject is included in the regional development plan which has currently been developed.

The basis for the initiatives undertaken by the metropolitan regional government can be found in the Preventive Plan for Atmospheric Pollution (art. 118 of PPDA 2010) through the following programmes: a Master Plan for Bicycle Lanes; a street cleaning programme; a modification of the PRMS 100 (not led by the Regional Government, but approved by the Regional Council); and international agreements such as the Mexico City Pact (Pacto de Ciudad de México) and participation in the C40 network. Furthermore, a series of regional studies are proposed, such as the study of the use of firewood for home heating (awaiting approval), an update of the Master Plan for Bicycle Lanes and its specifications (in development), and a feasibility study of public bicycle rental (awaiting approval).

(b) Key issues

The National Climate Change Action Plan focuses specifically on mitigation measures; it has very little content in terms of adaptation. The plan has a clear sectoral organization which considers critical sectors and infrastructure, but not social groups or urban infrastructure as a whole. As a result, there are no city-related criteria to guide the preparation of adaptation measures at the urban-regional level; and there is no urban planning instrument that responds to climate change (Krellenberg & Heinrichs 2011).

At the national level, the main discussion topics on the country's vulnerability to climate change concern temperature change and/or change in rainfall rates. The potential impact on the following industries, services, natural resources, and weather events in the country is also considered: mining, water resources, agriculture, animal husbandry, fishing, aquaculture, health, hydroelectric generation, ports, forestry, drought, floods, and storms. The effects of potential changes are assessed as positive, negative, or even uncertain. From an economic point of view, Chile is considered a vulnerable country in which the economic impact and potential economic losses caused by climate change could be significant.

General issues at the national level are centred on the following: water resources, glaciers, biodiversity, urban coastal regions, the agro/forestry sector, energy, infrastructure, health, and the fishing industry. At the local level, actions are concentrated on reducing the emission of gases and particulate matter.

(c) Integration of existing plans and policies

The greatest progress in adaptation on the national scale has been made in agriculture, which has always had to cope with climate change. Instruments and programmes such as insurance and an early warning system already existed, but now are included in an integrated risk management programme. As concerns the agro/forestry sector, an adaptation plan has recently been put into effect, and it is ready to be implemented at the national level. Therefore, the successful sectors in terms of adaptation to climate change are precisely those whose success is climate-dependent (agriculture), or more specifically, those which have always dealt with the negative impacts of climate uncertainty (for example specific insurance issues).

At the regional level, strategies to cope with climate change should be coordinated with other initiatives led by the regional government , such as the Preventive Plan for Atmospheric Pollution (Act

No. 118 PPDA 2010), the Street Cleaning program, aiming at reducing suspended particulate matter (PM10), the Master Plan for Bicycle Lanes which aims at promoting non-motorized transportation, and the amendment of Santiago's Metropolitan Regulation Plan (PRMS 100o) recently approved by the Regional Council, which greatly increases the potential urban area and hence the potential scope of climate change adaptation strategies.

Future initiatives currently pending approval include the following:

- Fostering the efficient use of firewood for domestic heating, with the goal of minimizing emissions through more efficient practices, techniques, technologies and management;
- An update of the Master Plan for Bicycle Lanes and its specifications;
- A study of the feasibility of public bicycle renting.

Other regional-level plans and territorial planning instruments of importance for climate change adaptation measures are: (i) the Regional Strategy for Development (ERD) at a final stage in 2010; (ii) the Regional Land-Use Plan (PROT), currently in preparation; (iii) the Strategic Environmental Evaluation , defined by Act No. 20,417, enacted in 2010; (iv) the Preventive Plan for Atmospheric Pollution and; (v) the amendment to Santiago's Metropolitan Regulation Plan (PRMS 100 modification). As a specific example, the Regional Strategy for Development (ERD) defines priority measures for climate change policy, such as improving the distribution and quantity of green areas in the region, promoting cycling and walking, and the measures outlined in the Greater Santiago Water Sanitation Plan.

(d) Institutional responsibilities

In Chile, the Ministry of Environment is responsible for the preparation, coordination and supervision of the plan's actions. The new law assigns responsibility for climate change policy to the new Ministry of the Environment although in practice different ministries draw up and send plans to the Ministry of the Environment, which then organizes a type of public consultation. The issue of the correct scale on which climate change adaptation policies should be formulated remains an open question: specifically, whether the policies should be regional or national.

The most important problem for urban planning institutions, in terms of both urban development and climate change, is that the instruments available are indicative and mostly not binding. There is also a need to coordinate infrastructure projects and territorial planning instruments such as the municipal land use plans (PRCs) and Santiago's Metropolitan Land Use Plan (PRMS). Lastly, better institutions and governance are needed in terms of citizen participation and communication measures.

Furthermore, at the metropolitan level a city mayor's office or similar institution is needed to lead the process, with the ability to take decisions beyond the local community level, but independently of the national level. The key challenge for climate change adaptation in Santiago is hence the lack of a rapid response policy, in other words the lack of a regional-level legislative assembly. For the moment, a set of decentralization measures has been submitted to Congress and includes the direct election of the regional councillors, and the election of the president of the Regional Government by the Regional Council. This will have budgetary consequences, amongst others, since up to now financial decisions have been made on a per-project basis, and the new structure will be based on an annual budget. This important institutional improvement is also related to the increasing legitimacy of regional governments.

As a result, a number of measures proposed in the field of governance have been mentioned, in addition to the question of how to generate institutions capable of leading climate change policy.

These include:

- To implement an accountability system;
- Ensure that the established measures are binding;
- Enhance representation at the regional level by, for example, ensuring a direct election system for regional councils;
- Rather than introducing new regulations, existing instruments need to be made to work;
- Guarantee the continuity of the technical-administrative body in public institutions, to prevent knowledge being lost, and make it possible to implement the plans in the mid-term;
- Express the regional priorities as items in the national budget, or to take the national budget to the regional level.

(e) Financing and evaluation of existing measures

For Santiago, tracking emissions is part of the Santiago Pollution Prevention and Decontamination Plan (PPDA). At the national level, there are non-regionalized measures of sectoral consumption of energy. Currently, there is an ongoing national study for evaluating the social impact of climate change, and an ongoing evaluation of the measures recommended by the National Climate Change Action Plan (PANCC). Benefits of climate change policy in urban development need to be highlighted.

Possible financing mechanisms at the national level are an adaptation fund (still to be created) as well as ministry-backed sectoral funds at the regional and national level. The main challenge is to establish climate change as an issue on the political agenda. And the most important, as well as the most difficult, aspect in building consistent adaptation plans is how decision makers legitimize resource allocation. Decisions need a level of certainty. It is important to define a methodology for identifying budgets and compliance indicators in order to facilitate resource allocation tasks for decision makers. Chile's experience consists of an academic approach to implementing an evaluation system based on a United Nations methodology, with the cooperation of the UNDP. The experience has, however, been complicated by the lack of information for evaluating costs.

(f) Obstacles encountered and progress achieved

In Santiago, progress includes a national analysis of the reduction of water flow in rivers, and the vulnerability of the agro/forestry sector and biodiversity in the face of climate change. A Regional Plan for Adaptation to Climate Change has been created in cooperation with the CAS project, and it has been integrated into the responsible institutions in November 2012. Progress has also been made in human resources. At the national level, progress has mainly been made in terms of mitigation. A decrease in GHG emissions was achieved for the entire country between 1999 and 2009. Furthermore, energy efficiency criteria have been incorporated into the construction of new houses, and non-conventional renewable energy has been incorporated into the national market by National Act No. 20,365. Furthermore, 320 km of bicycle lanes have been constructed.

The main obstacles to measures are the failure to cover climate change in public policy and to include the corresponding items in the national budget. There is also a lack of a regulatory framework and political will, and a dearth of basic information. This is due to the fact that the Metropolitan Region does not have a suitable monitoring network. Another problem area is water resources, given the reduction of water flow in rivers and the retreat of the glaciers that feed those rivers. The extraction of drinking water and overselling of water rights is also a significant issue. Today, there is a lack of public information on natural resources, partly owing to the privatization of water resources through water right concessions.

Major obstacles arise from the poor design of institutions for intersectoral and supra-municipal coordination, relating to the challenge of creating regional governments with greater legitimacy and wider powers.

F. Climate change policy in São Paulo

(a) Existing policies: background and scope

In the case of Brazil, three administrative levels for specific climate change policy exist. At the national level there is Decree No. 6263 of 21/11/2007, which established the Interministerial Committee on Climate Change (CIM) which guided the development of the National Climate Change Plan. In addition, Federal Act No. 12,187 of 29 December 2009, established the National Climate Change Policy (PNMC). The state of São Paulo launched a climate change policy in the form of a state climate change programme called PROCLIMA, through Resolution No. SMA 22/95, aligned with Act No. 13,798, of 9 November 2009, which created the climate change policy of the state of São Paulo (PEMC).

It should be mentioned that the city of São Paulo began its climate change policy before the state of São Paulo, in a process that was led by the mayor. A climate change policy exists at the prefecture level in São Paulo: the "Guidelines for the action plan of the city of São Paulo for mitigation and adaptation to climate change". It is based on the new law on climate change at the municipal level (Act No. 14,933 of 5 June 2009). There exists a relationship with districts whose representatives are appointed by the prefect, and therefore are responsible for implementing the policy defined for all of São Paulo, for example, in the area of risk control. This policy operates at the level of the city and the prefecture of São Paulo, and has the third largest budget for this purpose. This budget is not under the control of the Governor of the state of São Paulo (which has the second highest budget in country), so coordination between the two budgets is the key.

The Climate Change Committee, at the municipal level, holds monthly meetings in which citizens, institutions such as the International Council for Local Environmental Initiatives (ICLEI), universities and the government participate. All municipal secretaries whose work is related to environmental issues are members of this committee, and in this manner, policies are better integrated by the secretary in charge of overall city planning.

(b) Key issues

In order to develop an inventory of greenhouse gases, mitigation is clearly the focus of the state of São Paulo, which is working with the federal government in the dissemination and implementation of international agreements. The key impacts of climate change in the Metropolitan Region of São Paulo are related to the location of homes in hazard areas, which are mainly susceptible to landslides and floods. There is also a great need to protect water resources due to the interface between the problems of urban growth, pollution and altered rainfall patterns. Generally, the issues highlighted are: environment, infrastructure, utilities, risk areas, and housing ("urbanization" of the favelas).

The problem of the costs and the conflicts of avoiding hazard areas by evicting the inhabitants must be noted. A central policy concern is the large number of people living in situations of risk, who require relocation; but there is a shortage of social housing and a high housing cost in the city. When there is no opportunity for adequate housing close to the current location, it creates many conflicts. What is currently done is to maintain the current location of people through verticalization, which also means a change in culture and an extra effort to help people adjust to living in apartments.

(c) Integration of existing plans and policies

In the Metropolitan Area of São Paulo, environmental policy and housing policy are directly linked. The most important adaptation measure is, in fact, to formalize irregular neighbourhoods, beginning with public services and housing. Billions of dollars a year are spent on the transformation of these neighbourhoods. The Provincial Emergency Council works with civil defense and health authorities, as well as the provincial agency for sustainable development, facilitating emergency management and incorporating the issue of climate change. Links are also being made between climate change adaptation and policies on protected areas and fiscal water resource policy.

Policy action changes must be analysed to test the development policies in the centre of São Paulo, in high density areas. In urban areas there are vacant, unused, spaces near places with a high concentration of activities.

(d) Institutional responsibilities

In Brazil there are many laws and regulations, but there is a need for more fluidity in the process. Measures are defined at the three different levels of government (federal, state and municipal). For example, there is a federal law on climate change, but also a state and municipal law. As a consequence, there are three laws and three policies that coexist. However, the instruments and actors are clear for each. The actors are governmental, and also include private entities and discussions forums or committees to ensure participation in the process.

At a national level, the issue of climate change is coordinated by the Civil Office of the Presidency of the Republic (Casa Civil da Presidência da República), comprising 17 federal agencies and the Brazilian Forum on Climate Change (FBMC). Statewide, the coordination functions through the Global Issues Sector and Multilateral Agreements Company of Environmental Sanitation Technology (CETESB). In the city of São Paulo there is the Municipal Climate Change and Eco-economy Committee, consisting of municipal, state and civil society representatives.

(e) Financing and evaluation of existing measures

There is a management tool for the evaluation of measures in São Paulo that consists of a set of targets which needs to be expanded. In terms of financing, there is a specific budget for climate change adaptation. The law for climate change policy (at the federal level) states that formal financial institutions will provide credit lines and specific funding for the development of climate- related actions. In the case of the municipality of São Paulo, the tools, information and oversight are associated with economic mandates.

Financing policy measures should be considered a priority for implementation. In order to "sell" a project, both its viability and its long-term benefits have to be demonstrated. For example, the return on investment can be in terms of social benefits, not only income. There have been prior experiences with funds for urban environmental issues in São Paulo, such as a sanitation fund and a housing fund, but the management of specific funds is made more difficult by the diverse interests each of its directors. Therefore, deciding the percentage of the budget to be allocated to adaptation measures is a political decision. For example, housing has a total annual budget of US$ 1 billion, of which 90% is dedicated to the rehabilitation of slums, while the budget allocated to the environment is only about US$ 100 million.

One key goal is to involve financial authorities, particularly the Ministry of Finance, and engage them in climate change policy. However, it is important for them to have an interest in the subject. For this to happen, local and immediate benefits as well as co-benefits must be demonstrated. While a very direct link can be made to development in general, it must be emphasized and measured to make it attractive to those who provide the funds, and to the local authorities.

In general, in Brazil there are several viable funding sources for adaptation such as the National Climate Change Fund, the Support for Clean Development Mechanism program, and specific credit lines offered by the Federal Savings Bank (Caixa Econômica Federal).

(f) Obstacles encountered and progress achieved

In São Paulo, the most visible achievement is the reduction of risk-prone areas. Monitoring takes the form of mapping the population at risk. Adaptation measures that have been implemented include the creation of parks, called "linear parks", and the expansion of the wastewater collection system. There is an incentive to offer high-capacity public transport. Climate change legislation has been adopted at the three administrative levels and entities have been set up at the local level that include civil society and different levels of the administration (Committee on Climate Change).

The difficulty of balancing the different aspects of social, economic and environmental development represents a major obstacle in São Paulo. Aside from the diversity of interests and socioeconomic groups, there are different administrative levels, all highly relevant: includingthe federal, state, and metropolitan level.

G. Summary of existing plans, programmes and laws

Table IV.1 summarizes all of the plans, programmes, and laws that are in place at the different levels in each of the countries that form part of the Regional Learning Network.

H. Comparison between cities

According to the analysis carried out within the Regional Learning Network some activities stand out to decision makers as being particularly crucial to climate change adaptation.

With respect to progress already made in the various cities, the most important has been the incorporation of climate change adaptation in urban and environmental policy in the Metropolitan Area of Lima and the Federal District of Mexico, as well as the expansion of the wastewater collection system in São Paulo. In Chile, the incorporation of energy efficiency in new housing construction, agroforestry vulnerability analysis, and the reduction of river flows are of great importance.

It is appropriate to highlight the annual evaluation of adaptation measures in the Climate Action Programme (PACC) of Mexico City, and the cost-benefit evaluations made of the adaptation measures of the National Integrated Pilot for Adaptation in Bogotá. In Lima, it is the monitoring and evaluation system of the plan that is worth mentioning. From an academic perspective, there is concern about the need to evaluate and arrive at concrete data. While cost-benefit calculations are not the solution, resisting a quantitative argument contradicts the logic of the political way of thinking, which does require knowledge of how many degrees the temperature rises, how many individuals contracted dengue fever and what the associated cost is. Since this does not always correspond with academic rigor, the challenge is to find a viable methodology. One proposal follows Stern's argument of working with ranges.

To understand the financial implications of adaptation, a cost-benefit assessment and a socioeconomic analysis of the impacts of climate change are viewed as important. Regarding possible financing for adaptation measures, there are various funds such as the Adaptation Fund, the National Regional Development Fund (FNDR) and sectoral ministerial funds in Chile, as well as public funds, environmental and municipal revenues in Colombia. Of great interest in relation to financing are economic and fiscal incentives, and carbon and automobile taxes.

TABLE IV.1
SUMMARY OF EXISTING PLANS, PROGRAMMES AND LAWS

	Background and scope of programme	Main issues and key impacts	Links with existing plans or instruments	Measures to comply with programme
Argentina (National level)	National Climate Change Strategy (in development phase). National communications.	Disasters. Floods. Desertification. Agriculture. Water Resources. Glaciers. Coastlines.	Governmental Climate Change Committee.	Monitoring. Measurement.
Buenos Aires (Provincial level)	Provincial Mitigation and Adaptation Strategy (in development phase). Climate change vulnerability and adaptation for management and local planning.	Disasters. Floods. Desertification. Agriculture. Coastlines.	Provincial Climate Change Council. Provincial Emergency Council. Round table discussions. Platform linking sectors and decision makers. Bottom-up approach.	
Buenos Aires (Federal Capital)	Buenos Aires Action Plan 2030 (Federal Capital level).			
Colombia (National level)	Pilot: Integrated National Adaptation Plan. National Climate Change System End of 2013: National Action Plan for Adaptation.	Floods. Health (dengue fever). Ecosystems.	National Planning Department (DNP) responsible for the development of the climate change plan. Continuous and participatory process to generate adaptive capacity and decrease vulnerability. Pilot projects, education and awareness-raising.	Reduce GHG emissions (mitigation). Agricultural and ecosystem vulnerabilities. Joint integration programme of ecosystems and adaptation to climate change, various projects.
Bogotá (Metropolitan level)	Current development of the Bogotá-Cundinamarca Comprehensive Regional Climate Change Plan (PRICC).			
Peru (National level)	2009: National Climate Change Strategy. 2010: Action Plan for climate change adaptation and mitigation.	Diagnostics of risk-prone areas (hazards: floods, heavy rains, landslides, avalanches, droughts, frosts).	Municipal modernization programme.	Reduction of threat exposure. Evaluation guide for fragility, resilience and response capacity.

Lima (Metropolitan level)	Metropolitan Climate Change Strategy in development. Metropolitan Prevention and Disaster Risk Reduction in development.	Water scarcity. Floods. Landslides.	There is no management tool in process, key challenge in integrating adaptation. Metropolitan environment policy to be approved. Regional Coordination Development Plan under development. Land-use plan of the three river basins under development. Metropolitan Environment Agenda of MML 2011-2014 in development. Integrated management of river basins (River Basin Council).	Regional system of conservation areas (coastal Lomas of Lima). Metropolitan Green Area System (14 parks; the goal is 20). Nuevas Limas: south and north. Protected and regenerated waterways. Water conservation (sustainable irrigation). Mitigation of disaster risks. Urban agriculture.

Table IV.1 (concluded)

	Background and scope of programme	Main issues and key impacts	Links with existing plans or instruments	Measures to comply with programme
Mexico (National level)	June 2012: Strategy for Reduction of Emissions and mid-term resilience.		Consultation workshops.	Confronting vulnerability (current and future) to possible threats (includes economic evaluation). Development of vulnerability maps and atlas, by sectors (health, biodiversity, water, economic sectors, agriculture). Recommendations on finance.
Mexico City (Federal District)	2008: Mexico City Climate Action Programme (PACCM). 2011: Federal District Act on Climate Change Mitigation and Adaptation and Sustainable Development. 2012 Adaptation programme in effect.	Mitigation: transport, energy, reforestation. Adaptation: agriculture, health, biodiversity, rain, vulnerability, landslides.	Links with academia.	Concrete adaptation measures (24) with deadline. 74 measures in total, with definition of responsibilities and indicators (results pending).
Chile (National level)	National Climate Change Action Plan (2008-2012).	Overall mitigation. Vulnerable sectors: water resources, glaciers, biodiversity, health, energy, agriculture, infrastructure, coastal cities.	Agriculture (most advanced, insurance, early warning). Infrastructure (not far advanced, incorporation in regulation plans). Replication of regulations (e.g., reducing pollution) for climate change.	Adaptation by sectors (agriculture, fishing, biodiversity, water resources). Inventories, trends. Desalinization plants. Risk management. Emergency prevention.
Santiago (Metropolitan level)	Regional adaptation plan and manual for implementation (from CAS project). Regional Development Strategy (ERD).	Green areas. Energy efficiency (Mideplan, 2007).	Regional development strategy. Modification 100 PRMS. Environmental strategy evaluation. Preventive plan for clean air. Regional land-use plan (PROT). Plan of works.	Key sectors: water, energy, land use (hazards: floods and extreme heat), social vulnerability. Focused on mitigation: bicycle lanes and bicycle rental, energy efficiency, green areas, firewood.

Brazil (National level and state of São Paulo)	National climate change plan (Act No. 6.263). State climate change policy (PEMC). State climate change policy (PROCLIMA).	Mitigation.	Civil Office of the Presidency of the Republic (National). Brazilian Climate Change Forum (National). CETESB (São Paulo state).	
São Paulo (Metropolitan level)	Climate change policy of the Municipality of São Paulo (Act 14,933). Specifications for the Climate Change Mitigation and Adaptation Plan for the city of São Paulo.	Mitigation. Risk areas. Protection of water sources. Environment. Infrastructure. Public services. Housing (favelas).	Fiscal policies and water resource protection. Protected areas. Housing policy. Water infrastructure. Municipal climate change committee.	Numerous mitigation actions. Adaptation: urban parks, planting trees, forming favelas, environmental recuperation (along rivers).

Source: Prepared by the authors on the basis of the presentations of the workshop participants.

However, there are several obstacles to the implementation in the six cities of the Regional Learning Network. The main obstacles are the allocation of the national budget, access to funding, and limited capacities, in terms of inter-institutional coordination and the integration of measures at different administrative scales. The lack of monitoring infrastructure and the lack of public information online also appears to be a major obstacle.

Aside from the above, projects and measures considered most urgent and most important for implementation according to the participants of the workshops are the conservation and efficient use of water resources, the adaptation of urban drainage systems for dealing with flooding, the reduction in the number of people exposed to hazards through the elimination of risk-prone areas, resettlement and the implementation of an early warning system.

V. City perspectives and adaptation measures

To date, knowledge regarding specific climate change adaptation measures remains scarce. That is why this document attempts to summarize the adaptation measures that are under way or planned in the six cities in the network. Providing a framework and context for a discussion on those adaptation measures, calls first of all for a discussion on the future, a look at urban trends and the predominant structures taking a long-term view through to the year 2050. These elements are presented in this chapter and serve as a basis for understanding and discussing the specific measures. During the Regional Learning Network workshops the participants worked on this long-term vision precisely to develop a better understanding of and an in-depth discussion on specific long-term adaptation measures, but that includes short-term actions.

A. City vision for 2050 based on current trends

Common themes in the six cities are: (i) sustained population growth, albeit at a slower pace than in previous decades, and; (ii) greater well-being or, more precisely, higher incomes. These two trends create a significant increase in the pressure on natural resources, both in terms of consumption and the resulting increased demand for water, food, energy, etc., and in terms of occupation and development of land, air and aquifer pollution. Another question to be discussed is the spatial pattern of this growth. Urban housing density is increasing, yet without abandoning the expansion model of growth, thereby following a mixed logic.

In socioeconomic terms, common elements are the high inequality and sociospatial segregation, which are unlikely to change dramatically by 2050. The problem of poverty remains highly relevant, but important strides in combating extreme poverty and its direct consequences can already be noted.

In general, there is a common and apparently widespread tendency at this juncture in human history to resolve the various challenges by implementing technical measures, investments in infrastructure, management improvements and innovations. In this sense improvements in public transport systems, infrastructure, efficiency in water use and levels of contamination are expected; but the possibility of less technical measures has not yet been explored.

The nature of the vision for 2050 is thus necessarily ambiguous, and this is reflected in the following two statements by the panellists (seemingly contradictory, but ultimately complementary), noting the general trends mentioned above:

- *"If we continue as we are, we are not going to get very far, or things will even become worse."*
- *"The technological development will automatically begin solving some of the problems."*

Below are specific comments for the future of each of the six cities discussed.

Bogotá

With regard to the trends observed in Bogotá, assuming a *business as usual* scenario, the first noteworthy element is the spatial pattern of urban and population growth. There is a trend of migration to the city centre, as a result of attempts to revitalize historical centres. At the same time, there has been a trend towards the urbanization of the south-western areas of the capital district of Bogotá, inhabited mainly by lower-income groups of the population. Since these areas are more exposed to potential floods by the Bogotá River, and because climate change will cause the river flow to increase, a growing proportion of the population will be exposed to flood hazards. In general, recent major housing projects for the poor, of about 20,000 or 30,000 dwellings, are located outside the city, in nearby municipalities. To the north of the capital district of Bogotá, low-density suburbanization is taking place, but with higher land prices. This area is of high ecological valuable, containing aquifers, forest reserves and ecological connectivity that the region should retain.

In terms of land use, the predominant model is of a "city for those who can pay", and the most expensive and best located places are of greater ecological and environmental fragility.

Socioeconomic inequalities can be expected to persist, despite attempts to rectify them. Nonetheless, social policies are expected to bring about a real reduction in poverty in the country.

Urban transportation is important, since it regulates land use, mobility is a key issue and the actions taken by the current government will, in the long term, lead to a reorganization of the territory for the entire twenty-first century. There are plans for a light railway, a metro system and for improvements to the Transmilenio bus system in order to cover all the different modes of transportation, including the introduction of electric cars. However, the planned metro system will quickly reach its maximum capacity if the population continues to grow.

One issue that has received less attention but should be considered crucial is the impact of megacities on the regional resources of the environment, since larger populations will require more energy input and food resources.

Buenos Aires

In Buenos Aires, steady population growth is expected, which is increasing pressure on resources as there is more demand for energy, urban transportation, waste disposal, etc. Water and air quality is already deteriorating. In addition, there is a trend of increasing GHG emissions.

In terms of spatial structure there is a clear tendency towards compaction. In Buenos Aires, this is seen first of all in the process of replacing houses with high-rise buildings. In the centre of the city, high-rise buildings are getting taller, which puts added pressure on resources because there is more demand for energy. This occurs, for example, as a result of the creation of shadows within the city that generate the need for more lighting.

Other difficulties now and in the future are related to governance, the historical differences between the city and its surroundings, the urbanized townships that form part of the province of Buenos Aires. An improvement of intersectoral coordination is also the key, as there are different authorities under the same political wing. This is seen, for example, in how water resources are managed: in the province of Buenos Aires the issue of water is divided between three institutions.

Nonetheless, improved information on the environment is required: a climatic, meteorological, and hydrological warning system was implemented, called "Remote Monitoring and Environmental Warning Networks," but it is partial and not yet used for the entire metropolitan area, only for the province of Buenos Aires.

Lima

In the case of the Peruvian metropolis, while population growth is still expected in the short term, there are also signs of exhaustion of long-term population growth, so it is expected to stabilize at around 11 million or 12 million inhabitants by 2050, creating a quasi-limit regarding the ecology and functionality.

In terms of socio-spatial segregation there is little hope for an integrated city in the short term, but potentially there will be a number of cities segregated from one another.

The issue of the natural resources required by the metropolis and its relationship with the region/country as its supplier is very evident in the case of Lima, as it can be labelled "a parasitic city". The city generates financial resources by exporting the country's natural resources, which it then spends on many activities in the metropolis. Lima also depends on food, water and raw materials from its surrounding areas.

Despite these negative findings, there are some elements that allow for optimism. First, the planning process has resumed and there are a number of policies and plans in which a climate change approach may be integrated. Moreover, the conditions for integrated management of water resources are good, and the city has a water law that allows for watershed governance. Moreover, being a desert town, the city is implementing and promoting increased green areas with sustainable irrigation on a micro scale in many areas. It is estimated that, depending on the nature of human development, there will be a technological progress that will start to solve some of the problematic issues. This may manifest itself, for example, in the field of urban transportation as technologies such as hybrid cars and the implementation of cleaner technologies with lower emissions per kilometre help reduce polluting emissions and secure more efficient resource use. It also seems that in response to demand and thanks to recent progress, two additional mass transit systems are going to be introduced.

Mexico City

Regarding the spatial pattern of urban growth in Mexico City, there has been support for the recovery and promotion of the city's centre. However, at the same time the metropolitan area is expanding into peri-urban areas, which are seeing the fastest growth even though they are outside the Federal District for the most part. Even so, by the year 2050, Mexico City is expected to have densified significantly and will take advantage of its existing infrastructure by implementing a more efficient public transport system, while also including spaces for walking. This optimistic outlook is based on the experiences and successes of the Federal District. In comparison with the early 1990s, Mexico City is now a much cleaner city with a better transport network and better public transportation. In particular the issue of urban transport serves as a good example of the public-private development models implemented in the city, for example the Metrobus, a BRT (Bus Rapid Transit) system that completely covers one of the city's main avenues (Avenida Insurgentes). On the other hand, it is a city with a very high level of congestion and a high motorization rate, which means that even if you solve the challenge of lowering GHG emissions through alternative systems and technological innovations, the problem of congestion will persist. To address this the use of private transport must be discouraged. If current trends continue, the transport situation will worsen.

It is important to recognize the great strides achieved in poverty reduction, and further progress is expected in future, though the problems of inequality and sociospatial segregation are likely to persist.

In Mexico City there is also a deterioration of natural spaces and changes in land use on a large scale, which is related to both informal and formal growth, gravely damaging existing ecosystems, generating significant losses in biodiversity.

Santiago

A "catastrophic vision" of Santiago suggests continuous urban growth through migration fuelled by the city's attractiveness to people from other regions and countries. Decentralization is not yet a reality in Chile. These trends create pressure on land use, energy and water, among other resources. They will also lead to degradation within the city. There are some districts that now project increased urban land depreciation, which over time will lead to a concentration of poverty within the Metropolitan Area of Santiago, not only in suburban and peri-urban areas, but in the city centre. This is linked to the issue of vulnerability in Santiago as the people living in the city centre will suffer most from the effects of climate change. Economic growth is also increasing pressures on the energy sector, and energy consumption is expected to double by 2020.

São Paulo

In terms of spatial structure, São Paulo is expected to become more compact, denser, with fewer vacant lots, and should experience a massive renovation of underutilized, precarious buildings. The Municipality of Sao Paulo is currently promoting São Paulo as a compact city in local urban policy. This means constructing high-rise buildings, but the priority is on repurposing underutilized or unused lots, areas and urban plots for urban regeneration, which will allow for development without expanding the city's limits.

Significant progress is expected in terms of the efficient use of natural resources, particularly energy sources. GHG emissions are expected to decrease under São Paulo state policy, which has the goal of reducing CO2 emissions by 20% by 2020. This translates into policies that promote the use of green ethanol and renewable energy. In relation to this, one of the main problems in the Metropolitan Region of São Paulo is the need for a substantial improvement of the public transport system.

An optimistic long-term vision for São Paulo includes the prospect of improved public-private institutions and increased coordination between municipalities and between different administrative levels. Significant progress has already been made in this field.

Three main policy priorities emerge from this vision: (i) to further improve the city's institutions; (ii) to ensure water provision, multiple-use water systems and the prevention of floods; and (iii) to combat traffic congestion, improve energy efficiency and enhance public transport.

B. Climate change adaptation measures

As noted above, humans have shown a capacity to gradually adapt to external pressures, environmental or others, which are not necessarily related to climate change. However, these adaptation processes have a cost, and that cost is greater in the case of delayed or ex-post adaptation. Nevertheless, this ex-post reaction can be considered a normal process and "our society assumes that adaptation costs are social costs," as stated by one of the workshop participants.

Consequently, this section discusses existing and potential early and preventive concrete measures for adapting to the effects of climate change that are most likely to take place, taking into account the measured effects of climate change presented in chapter III and the general trends observed in the megacities described in section V.A. It is important to note that these changes do not occur in isolation, rather they are closely related. Presented below is a combination of measures that are already in place and others that would be desirable. For each city a box text has been included giving one concrete example of good practice currently being implemented.

Bogotá

Increasing urban density and higher temperatures in Bogotá will accentuate the need for cooling mechanisms in the future.One of the most important measures of adaptation is in the area of building: the installation of ventilation systems or passive cooling systems. There is a tendency towards sustainable architecture, including the construction of environmentally friendly housing, in response to the expected future increase in temperature, caused by heat islands and global warming. To face these issues, consideration must be given to revitalizing the centre of Bogotá and introducing efficient housing projects together with the construction of green spaces.

Another area where significant impacts are expected is in relation to water resources. It is proposed that the differentiated cost of water consumption should be established not only on the basis of socioeconomic group, but also on the quantity of consumption, meaning that those who consume more would have to pay more for each unit of water. On the other hand, in terms of water availability, an approach that takes into account the size of river basins is crucial, even more so since the projected changes in precipitation differ between Bogotá (projected reduction in precipitation) and the wider region (projected increase). The regional Páramos Project has been developed in view of climate change, and another regional integration project is being carried out in conjunction with the government of the Cundinamarca region.

In terms of preventing the risk of floods and landslides caused by extreme rainfall events, the first step is to use urban planning to prevent the construction of settlements on sloping and low-lying areas on the banks of rivers, which entails reviewing the land-use model for the city and the region (see box V.1). It is also necessary to activate, strengthen and reinvigorate fire prevention campaigns in dry periods.

BOX V.1
MANAGEMENT OF RISKS ASSOCIATED WITH CLIMATE CHANGE IN BOGOTÁ: EXTREME EVENTS, LANDSLIDES AND FLOODS

Coordinating institution: National Disaster Risk Management Unit (UNGRD).

Colombia has a comprehensive and institutionalized risk management policy, which is partly related to climate change since risk management is one of the main measures of climate change adaptationThe institutional architecture in place and the specific measures that have been taken are outlined below.

UNGRD, which has administrative autonomy, was created by Decree No. 4147 on 3 November 2011 and is responsible for coordinating the National System for Disaster Prevention and Response (SNPAD). This system was established in 1989, but is now governed by the Act No. 15,323 passed on 24 April 2012 [http://wsp.presidencia.gov.co/Normativa/Leyes/Documents/ley15324042012.pdf]. Some of the measures taken by the institution are particularly related to climate change, such as the establishment of a climate change office in UNGRD and the coordination of the process of the National Climate Change Adaptation Plan. Measures are taken at different institutional levels, as evidenced by the preparation of the Municipal Guide for Risk Management (2009).

An example of the specific measures that are directly linked to climate change are those taken to address the risk of landslides. The Institute of Meteorology, Hydrology and Environmental Studies (IDEAM) publishes daily technical reports on the hydro-meteorological situation, issues alerts at the municipal level, and produces a daily forecast on the threat of landslides. The model for monitoring and forecasting the daily threat of landslides designed by IDEAM is based on the national map of susceptibility or propensity for the land to present mass movements, daily rainfall being a trigger for such events (IDEAM, [http://www.pronosticosyalertas.gov.col]).

Source: [http://gestiondelriesgo.gov/sigpad/archivos/GMGRColombia.pdf]; [http://www.dnp.gov.co/LinkClick.aspx?fileticket=UvySsHnUrjs%3Dandtabid=1539].

A revised land-use model is important on a macro-scale. In the context of climate change policy, it is necessary to coordinate a network of cities around Bogotá and promote development in other zones located in the city's surrounding areas. However, the aim is not to extend the Bogotá city limits indefinitely, connecting Bogotá with surrounding municipalities. A key issue in this connection is food security, which calls for a review of the ecological structure that supports the city in environmental terms. This raises the need to view Bogotá not only at the district level, but to look at its ecological structure from a regional perspective, taking account of its interconnecting orographic and water systems. The workshop participants highlighted the need to redefine the 2004 Land-Use Plan in the context of climate change policy.

There are a number of other soft measures, such as educational initiatives, cultural change, campaigns, efforts to change certain habits in order to promote the use of electric cars and to introduce more environmentally friendly transport systems, etc. A general problem with these measures is that they can generate costs or affect socioeconomic groups unevenly in other ways. In particular they risk hitting the poorest people hardest as they have fewer means to find or finance such alternative solutions. For example, in response to the traffic restriction programme in place in Bogotá, high-income households sometimes buy a second vehicle, which the poorest obviously cannot afford.

Buenos Aires

In view of the increased flood risk, a key role has been assigned to early warning systems and urban signposting in Buenos Aires. It is worth bearing in mind that adaptation does not necessarily mean minimizing the hazard, it can also involve warning and prevention measures, which can be much less expensive. There are certain streets in Buenos Aires that are known to be prone to flooding. However, there is some resistance to identifying these streets as such signposting can bring down property values, but from the point of view of prevention it is important to indicate which areas of the city's streets are passable and which are not.

In terms of energy policy, measures taken to increase energy efficiency may not be explicitly related to climate change adaptation, but can nevertheless have an impact on adaptation. Energy efficiency measures are more appropriate than, for example, the promotion of the use of renewable energy, given the average number of cloudy days in Buenos Aires. These measures are implemented above all with a view to mitigation and are seen as attractive mechanisms that have economic benefits.

In terms of housing, important climate change adaptation measures would be to consider the vulnerabilities within construction planning. Procedures should be implemented to make buildings less vulnerable to extreme weather events. For example, many people lose their homes owing to strong winds.

In the Autonomous City of Buenos Aires, a number of specific measures exist, but most of them fall within the category of mitigation, such as the "Ecobus", the recovery of methane from landfills, bicycle lanes and energy efficiency courses for small and medium-sized enterprises (SMEs) among others.

Adaptation measures include the following (Buenos Aires, 2011, p. 30):

- The use of green roofs, which primarily help lessen the effects of extreme temperatures and the urban heat island. They are particularly important in areas with few trees. Other measures of urban design and green corridors also point to the problem of heat islands and problems in ventilation, emphasizing the role of trees and vegetation in general in the context of adaptation;
- Incorporating the planting of trees in local policies and creating a census on tree species;
- Implementing drainage systems and adapting to the threat of increased extreme rainfall events in order to limit flooding;

- Creating better management of the Matanza-Riachuelo river basin by relocating vulnerable communities living in poor housing at the river's edge. This serves as a way to reduce the risks associated with the increased probability of rainfall events exceeding 30mm in 24 hours, which causes flooding in these areas;
- An important element in the politics of climate change adaptation in the city of Buenos Aires is the recognition of the need for more information (see also the Act No. 3,871, referred to below), which advocates better weather stations;
- In terms of health, climate change causes new diseases and promotes the spread of tropical diseases, therefore requiring a policy to combat the resulting risks (see box V.2).

Another important element is the passing of the Climate Change Adaptation and Mitigation Act in the Autonomous City of Buenos Aires (No. 3,871) in 2011, which defines the actions and minimum adaptation measures in Article 18. However, these measures, which are grouped into categories of water resources, coastal areas, health, the industrial and energy sector, urban development and tourism, are mainly geared towards the need to evaluate and study the impacts of climate change and the possibilities for action. See [http://www.cedom.gov.ar/es/legislacion/normas/leyes/ley3871.html].

BOX V.2
ADAPTATION TO CLIMATE CHANGE AND HEALTH IN BUENOS AIRES: COMBATING HEALTH RISKS AND THE RISE OF TROPICAL DISEASES

Executing agencies: Ministry of Environment and Public Space and the Ministry of Health.

The tropicalization of the city's climate is creating prime conditions for the spread of dengue fever, which is transmitted by mosquitoes. Because of its specific form of transmission, favoured by higher temperatures, ideal humidity levels and bodies of water, fumigating the city's green areas is therefore one of the most important measures that can be taken to limit the spread of the disease. This measure is combined with programmes to provide training on and raise awareness of this new health risk, as well as the implementation of a surveillance network through health service providers.

Source: City of Buenos Aires, 2011, [http://www.buenosaires.gov.ar/areas/med_ambiente/dengue.php?menu_id=30,236].

Lima

The first key issue in terms of adaptation in Lima is to ensure access to water and its efficient use. The local water company makes efforts to divert the rivers on other side of the upper catchment area and direct them to Lima, but there is a huge amount of water loss, leakage and misuse that could be reduced. The national government, through the State-owned Lima Water Company, promotes the efficient use of water through financial or tax incentives and by applying tariffs according to social criteria. The first 10 cubic metres of water per year are priced at virtually nothing. But, as consumption increases, the price per litre of water increases exponentially. Therefore a significant water leak in the home can increase the next water bill to easily twice the minimum wage, which makes people worry about water leakages and thus reduces the problem.

Issues of water governance require greater regional cooperation, mainly between the metropolitan area and the upper basin. The law on water resources establishes the need to form water resource councils at the river basin level. In Lima, they must be led by regional governments and involve all stakeholders and users of the river basins. However, since the city is situated on three different river basins, there are discussions on how this situation should be managed and whether there should be three councils or just one.

Construction works relating to water resources have also proved important, and these do not necessarily have to be large-scale projects such as dams. Ancient techniques refer to "sowing water"

using simple, non-industrial technologies. However there is a need for construction projects, including projects to capture or retain water in the upper river basins.

There is also a problem of access to drinking water and the quality of water sold informally, which has prompted civil society organizations to react. These organizations distribute kits to people in poor communities and communities without access to safe drinking water, in order to enable people to test the quality of the water sold by street vendors. But this has been a citizen initiative, and the State, the State-run company and the municipalities have thus far failed to assume responsibility for this problem.

As for adaptation to higher temperatures, there is a need for a revision of building codes. Owing to the favourable, temperate climate and the prevailing socioeconomic conditions in Lima, there is a large amount of precarious housing that lacks thermal insulation. Efforts should be made to encourage passive cooling techniques and eco-efficient construction, rather than the installation of air conditioning. To give an example, one eco-efficient construction project in a poor area of Lima ended up being 10% more expensive, but after two years the amount of water and energy saved had already covered the price difference. For a long time the prevailing view was that infrastructure is expensive, and water and energy are free or relatively cheap. Now the situation has changed and both water and energy have become very costly, but there are no measures to adapt old buildings to the current conditions, and it is not something that is incorporated into the building code. Ultimately these choices are left to the discretion of the private sector, but, there should be some form of evaluation criteria or at least a system of labelling and the public registry of properties should have an obligation to display how much energy each housing project consumes. Construction standards would thus be required to cover new methods of climate control.

As for the health issues associated with climate change, there is a need to prepare for the possibility of new diseases, but the city has no jurisdiction over such issues because health issues are a national government responsibility. This bears a direct relation with drinking water, as the water treatment process is based on a self-purification mechanism, where the water is cleaned by passing it through microorganisms. With a rise in average water temperatures, even of only one or two degrees, these aerobic microorganisms can die, and diseases, especially gastrointestinal, can emerge in the water. Because of this, some of the adaptation measures relating to health issues need to address changes in drinking water infrastructure or treatment processes.

Administrative measures could also be considered, such as allowing more flexible work schedules, and shift changes.

In Lima, several environmental projects related to climate change are under way. One is the integrated management of river basins by a river basin council, which manages the Rímac River that provides 70% of the city's water. The Plan for Sustainable Irrigation for the city aims to substitute the use of potable water in the irrigation system for processed wastewater. Other projects relate to the recovery and enhancement of waterways including those of the Rímac River Park, the Lurín-Pachacámac River Park and the Chillón River Park. In order to harmonize the wastewater master plan with the green area plan, a dialogue was started with the public water company in Lima (SEDAPAL). Efforts will be made to recover wastewater, since the treatment plants currently built by SEDAPAL do not include wastewater recycling facilities. A mapping at the local level in terms of vulnerabilities, risks and solid waste plans, linked to the economic incentives mentioned above, forms part of the municipal modernization programme. Capacity-building, institutional-strengthening and improving public policy are also targets of some of the existing programmes.

In the field of governance and urban planning, there is a need to combine territorial, land-use and water policies. In this field, a close look should be taken at the changes needed in the current cost structure (infrastructure versus consumption) in terms of the value of private and common uses, as well as the, prioritization of certain uses over others. The concept of solidarity must be incorporated into the design of the policy system and into adaptation measures as a whole. The prevailing lack of solidarity and the predominance of an "every man for himself" rationale, means that measures, such as

contracting household insurance, can be taken only by the households that have the financial resources to do so. From a comprehensive viewpoint, this is extremely inefficient.

BOX V.3
LIMA: CLIMATE CHANGE ADAPTATION, GREEN AREAS AND URBAN AGRICULTURE

Coordinating institution: Municipality of Lima (partly supported by the Fund of the Americas, Peru).

Lima is implementing an urban agriculture programme called "My Garden" ("Mi huerta"), which includes over 2,000 productive green areas (gardens) for a total area of 450,000 m2. By promoting these activities, the city aims to obtain several benefits simultaneously: to maintain the city's green areas; to improve the urban environmental quality at the neighbourhood level; and to generate food especially for families in extreme poverty. Sixteen districts in Lima were chosen, which were considered to have most unfavourable socioeconomic conditions, high malnutrition levels and few green areas [http://www.munlima.gob.pe/programas/mi-huerta.html]. The programme aims to benefit approximately 30,000 people and costs US$ 2 million. It is funded by the Municipality of Lima and the Fund of the Americas, Peru [http://www.fondoamericas.org.pe].

While it is not a specific climate change adaptation measure to, it serves as such, since it encourages the development of productive green areas which could have an important role in the urban microclimate, and which also contribute to food security. Though it is a small-scale measure, it is making an impact in the neediest areas of the city.

These efforts are complemented with other measures that form part of the "Green Lima" project, for example, the xeric gardens programme, which encourages the use of water-saving plants, thus decreasing the use of irrigation water by up to 70%. This is combined with the use of treated wastewater for the irrigation of parks [http://www.munlima.gob.pe/programmes/adopt-a-arbol.html]. These two have a clear adaptation component as they promote the development of urban green areas, but in a way that conforms to the limited supply of water.

Source: Prepared by the authors, on the basis of [http://www.munlima.gob.pe] and [http://www.fondoamericas.org.pe].

Mexico City

At the programming level in Mexico City, there is a need to add a climate change adaptation strategy to the detailed climate change plan, which emphasizes mitigation efforts. This should be based on complete information, but unfortunately that is still lacking in terms of modelling the implications of climate change. Also, in the institutional sphere of urban planning for climate change, it is necessary to include adaptation actions in urban land-use plans. In administrative terms, the short duration of executive municipal terms of office (three years) means that the actions taken tend to be very short-term. In addition to a need for better coordination between different levels of the government, particularly between federal and local governments, technical capacities must be built among local decision makers. In Mexico City this is not so much of a problem, but in other cities decision makers often lack technical expertise. There is the suggestion to include adaptation action in future urban development plans.

PACC for Mexico City includes within its framework a Comprehensive Programme for Climate Change Adaption, which includes specific actions in the field of micro river-basin management, as well as forestry, agriculture and epidemiological monitoring in the health sector. The programme is financed by the World Bank and also receives funds from the Public Environmental Fund of the Government of the Federal District.

In the area of urban transport, one of the biggest challenges for the Valley of Mexico in terms of sustainable development is the implementation of more effective regulatory and economic instruments. One suggestion is to put quotas on the movement of private cars in the centre of Mexico City. The use of private vehicles in this area could require an additional payment and the increased

cost could discourage excessive car use. Parking meters could be employed to this end, but they should be combined with urban planning measures, such as the creation of pedestrian streets and bike paths —that is, an urban policy that facilities the use of low-emission vehicles.

A central issue and ongoing challenge in the Valley of Mexico, is the supply of water resources, which requires efficient structures for the distribution of drinking water to all socioeconomic groups in such a way as to generate the revenues needed to maintain the infrastructure, such as water treatment plants. It is also important to have resources to subsidize water consumption of lower socioeconomic groups. In addition, it will be important to increase the efficiency of the use of water resources, not only in terms of updating the infrastructure to minimize the amount of water loss, but also by recycling grey water.

With regard to housing and adaptating to the challenges presented in relation to improving efficiency and adjusting to the changes in temperature, both the Institute of the National Fund for Workers' Housing (INFONAVIT) and the Housing Institute of the Federal District (INVI) are implementing programmes for the housing of low-income groups (see box V.4).

BOX V.4
ADAPTATION AND CONSTRUCTION OF SUSTAINABLE HOUSING IN MEXICO CITY: GREEN MORTGAGES

Coordinating institution: INFONAVIT, Housing Institute of the Federal District (INVI).

The green mortgage ("hipotéca verde") is a line of financing for the acquisition of new social housing equipped with green technologies established by the Institute of the National Fund for Workers' Housing (INFONAVIT) in 2007. In the so-called "green homes" energy-saving and water-saving technologies are installed, such as thermal insulation, solar water heaters, energy-saving lamps and water-saving devices. Since these technologies are more costly than conventional technologies, the green mortgage is intended to provide an incentive for real estate developers to build homes with eco-efficient technologies and materials [http://portal.infonavit.org.mx].

The green mortgage is thus a good example of how to integrate mitigation into existing policies, in this case, within Mexico's housing policy. Not only does the programme achieve a reduction in GHG emissions, it also reduces household expenses by decreasing consumption of electricity, natural gas and water. While at first glance the project does more in the way of mitigation, the green mortgage has measures that can also be interpreted as climate change adaptation measures, such as household temperature regulation and savings in the amount of potable water used.

In the period 2007-2012, more than 1 million green mortgages were awarded to INFONAVIT homebuyers across Mexico. They are given an additional credit of up to US$ 1,250 on top of the credit they receive from INFONAVIT to cover the cost of installation of the green technologies.

The programme is one of the winners of the 2012 World Habitat Awards, awarded by the United Nations for projects that promote sustainability, improve the living conditions of inhabitants and empower marginalized groups.

The Housing Institute of the Federal District (INVI) is following a similar path with its sustainable housing programme in Mexico City, which includes the installation of solar heaters, rainwater harvesting devices and other eco-techniques in new housing developments. It also offers similar technologies in its programme for improvements in self-built housing. The Housing Institute also offers rewards to borrowers who meet the loan repayment date, for example, solar heaters, which allows households to save up to 70% of the natural gas needed for heating water [http://www.invi.dj.gob.mx/portal/sustentable.aspx].

Source: Prepared by the authors, on the basis of [http://portal.infonavit.org.mx] and [http://www.invi.df.gob.mx/portal/sustentable.aspx].

Santiago

The top priority and apparently the biggest challenge relating to climate change in the Metropolitan Region of Santiago is the increase in water stress,and shortages of water for irrigation are already a problem. To address this problem several measures are currently being discussed:

- Promotion of irrigation technology, mainly to support medium- and large-scale farmers to achieve greater efficiency in irrigation. The National Irrigation Commission of the Ministry of Agriculture is in charge of the measures in this arena. Therefore, in administrative terms, this is an issue that affects the whole country and not just the Metropolitan Region;
- Efficient use of potable water, mainly in residential areas. This issue currently falls under the jurisdiction of the Chilean Agency for Energy Efficiency, which is also a national institution.

These issues underline the need to promote research and development in technological solutions to the challenges of water stress, which requires political support for continued research on the topic. This responsibility falls not only to the government institutions that promote research and technology (CONICYT, etc.), but also to partnerships between universities and businesses. Today's technological innovations are directed towards promoting groundwater reuse, seawater desalination, wastewater recycling and the collection of rainwater in controlled spaces or tanks during periods of rainfall, among other measures. Regarding the management of water resources, there is a need to implement a model for the management of river basins where the actors involved can interact at a "water table discussion" along with government authorities and other actors.

Another challenge is the rise in temperature. Responding to this challenge calls for adaptations in the construction of buildings and a lower percentage of buildings and paved surfaces in order to reduce the urban heat island. Ongoing efforts consist in incorporating low heat-capturing pavements in the paving policy at a regional level in order to avoid heat islands. In terms of the buildings, there are programmes in place that include the sustainable construction of public buildings (for example, the Chilean Agency for Energy Efficiency). A central issue in terms of the link between climate change adaptation and sustainable development in the Metropolitan Region is the need to address the spatial and socioeconomic equity of the consequent benefits and impacts. On the subject of temperature increase, this means supporting the development of green areas and the recovery of vegetation. Key elements would be to create a development plan for planting vegetation in the city and, to protect and restore vegetation in the peripheral areas of the city. Even the implementation of certain technical measures for public transport, such as exclusive bus lanes, would reduce the exposure of lower socioeconomic groups to the risks of heat stress and the increased probability of health consequences. Such health problems can be exacerbated owing to the limited access that low-income groups have to health services.

BOX V.5
CLIMATE CHANGE ADAPTATION AS A CHALLENGE FOR REGIONAL GOVERNANCE AND PLANNING IN SANTIAGO: CLIMATEADAPTATIONSANTIAGO ROUND TABLES

Coordinating institution: ClimateAdaptationSantiago (CAS) project

The ClimateAdaptationSantiago (CAS) project organized a participatory process consisting of a series of ten round tables (2010-2012) at which representatives from relevant authorities at the national, regional and local level from the public and private sectors, civil society and academia came together to develop climate change adaptation measures. The main objective of the project was to develop a Regional Climate Change Adaptation Plan with concrete measures for the Metropolitan Region of Santiago.

Box V.5 (concluded)

The participatory nature of the process made it possible to examine scientific results in the light of the local knowledge of the participants. This is a relatively new approach in Chile, and harnesses the potential of an active civil society.

A total of 14 adaptation measures were devised, which reflect the issues and options that were considered most important during the round table discussions, that is, relevant to the objectives, appropriate to the local context, with a sufficient level of detail and viable for practical implementation.

In order to effectively implement these measures it is necessary to promote transparency, accountability, cooperation and collaboration between stakeholders and end users. This approach reduces many of the obstacles that could affect the practical implementation of the measures designed. The plan was submitted to the institutions responsible for implementation.

There are plans to maintain the participatory process of the CAS project through the government of the Metropolitan Region of Santiago — the most important stakeholder in terms of the implementation of the measures while a regional board on climate change table is being set up.

Source: Prepared by the authors [http://www.climate-adaptation-santiago.ufz.de].

São Paulo

The most important issue in São Paulo is water, both in terms of the access to water resources and in terms of risks (floods, landslides). Today, São Paulo is making great efforts to implement the necessary infrastructure, such as drainage pools and huge reservoirs for flood waters, but these efforts are still not enough (see box V.6). Consequently, a holistic view is needed in relation to water management, both in terms of rainwater, and in terms of water use by society. This includes the issue of water pollution because many rivers are already "dead".

BOX V.6
SÃO PAULO: ADAPTATION, REDUCTION OF FLOOD RISKS AND MULTIPLE-USE WATER SYSTEMS

Coordinating institutions: Municipality of São Paulo, in part with the support from the Inter-American Development Bank (IDB), and the Metropolitan Development Secretariat.

The most relevant projects relate to drainage infrastructure and water storage to reduce flood risk in São Paulo. These measures are not necessarily linked to climate change, but rather exist due to the combination of heavy rainfall events, insufficient infrastructure and informal development in risk-prone areas. Thus, prior to the discussion on adaptation to climate change, the city implemented large water infrastructure projects combined with the relocation of vulnerable populations. These included the

"Microdrainage programme in São Paulo" of the Inter-American Development Bank (IDB, 2007), with an investment of nearly US$ 300 million in the construction of canals to reduce the risk of flooding during the period 1995-2007.

The aim of the project is to set up a multiple use water system based on the construction of a ring of waterways, with a view to using water as a natural resource and to use the waterways for navigation and the transport of people and cargo, including solid waste. It is a very ambitious project, which would also serve to drain or collect rainwater and thus prevent floods, which are frequent in São Paulo. The Metropolitan Development Secretariat is coordinating this project, which will also involve several other secretariats.

Source: Prepared by the authors on the basis of the information presented in the workshop and IDB, 2007.

This holistic approach includes drainage, flood prevention and water access. The emphasis is on implementing plans and programmes geared towards combating flooding. More efficient channelling of urban drainage for rainwater is needed. The measures taken should also include plans for solid waste collection since the garbage frequently left in the street in São Paulo often blocks existing water channels. In terms of urban planning, although densification in keeping with sustainable development is necessary, the risk of rising temperatures due to climate change means that this measure must be combined with an increase in permeable urban spaces.

One practical measure for adapting to the increased risk of floods and landslides is the implementation of an early warning system in the city. This calls first for a better and deeper understanding of the expected impacts of climate change.

In general, the focus should be on fostering measures that promote the use of renewable energy sources and the establishment of public-private cooperation for adaptation.

C. Systematization of adaptation measures

This section contains a systemized summary of the adaptation measures proposed for the six megacities, using the format recommended by the European Environmental Agency (EEA, 2012). Table V.1 differentiates between the following measures: (i) infrastructure construction (grey measures), for example, retaining walls to reduce flood risk; (ii) increaseing vegetation and green areas (green measures), for example, green areas for flooding; and (iii) soft measures, which concern institutional actions to improve the management of adaptation, for example, the identification of flood-prone areas.

TABLE V.1
SYSTEMATIZATION OF ADAPTATION MEASURES

Metropolitan area	Grey measures (Infrastructure)	Green measures	Soft measures (institutional)
Bogotá	Buildings with passive ventilation and cooling systems.	Revitalization of the city centre with an increase in green areas.	Differentiation in water prices for different uses: scaled system.
			Preventing settlements on hillsides and riverbanks through planning.
			Risk management.
			Campaigns for fire prevention.
			Educational campaigns.
Mexico City	Pedestrian streets, bicycle lanes.		Development of adaptation strategy.
	Increased efficiency through recycling of grey water.		Discourage use of private cars.
			Include adaptation-oriented programmes in urbanization plans.
			Structure for the distribution of drinking water for all socioeconomic groups.
			Green mortgages (ecological housing).

Lima	Passive cooling and eco-efficient construction. Desalination of water. Reduce the extensive water loss, leaks and misuse. Treatment plants for wastewater and use of recycled water to irrigate green spaces.	Recuperation of vegetation (green areas). Green Lima and xeric gardens. My Garden ("Mi huerta") project.	Water as a common good: ensure the right to water for as there are still large segments of society without access to water. Promote efficient use of water through financial or tax incentives. Cooperation with upper river-basin zones. Water Resources Act. Building standards. Flexible working hours. Changes in the pricing structure (infrastructure vs. consumption) and value added. Need to coordinate territorial, land-use and water policies.

Table V.1 (concluded)

Metropolitan area	Grey measures (Infrastructure)	Green measures	Soft measures (institutional)
Buenos Aires	Use of better materials and reduction of the physical vulnerability of housing. Implementation of a rainwater drainage system.	Green roofs and incorporation of tree planting in local policy.	Warning systems and urban signposting. Promotion of energy efficiency. Combat sanitation risks and the rise of tropical diseases.
Santiago	Promotion of advanced irrigation techniques. Efficient use of drinking water. Refilling aquifers, desalination of seawater, recycling of wastewater, etc. Sustainable construction of public buildings. Transportation (exclusive lanes).	Fewer pavements to reduce the urban heat island. Recovery of vegetation.	Watershed management. Develop a plan for green areas. Thermal regulation in construction.
São Paulo	Drainage pools. Efficient urban rainwater drainage systems (canalization).	Increase areas of water permeation in urban areas.	Holistic vision of water management. Multiple uses of water. Plans and programmes to combat floods.

Source: Prepared by the authors on the basis of the workshop presentations and information from the European Environment Agency (EEA, 2012).

VI. Conclusions

Establishing a Regional Learning Network on climate change adaptation bringing together six cities of Latin America has been an exercise in sharing experiences that allows for comparisons on different levels. The first concerns the scientific data on climate change at the local level, both its manifestations and its impacts. It also highlighted the state of development of action plans and proposals for concrete adaptation measures. This document therefore provides an important summary of the current state of practice in urban adaptation to climate change in Latin America.

The information on regional climate change and its impacts is important and valuable for setting the scene. Although certain similarities were highlighted regarding climate change and its impacts, for example, in cities located in comparable climate zones, the political responses vary greatly from city to city. Therefore, the different paths taken by the cities were highlighted and the discussions that took place between local experts in the three workshops of the Regional Learning Network drew attention to both the progress made and the obstacles encountered in the process of climate change adaptation.

Despite all the uncertainties associated with climate change modelling and especially downscaling at the urban scale, one common element stands out: the alteration of the water cycle. Depending on the city's specific characteristics, this can lead to increased risk of flooding and landslides, on the one hand, and future shortages in the availability of water resources, on the other. A second common element, whose spatial and temporal distribution is even more uncertain, despite its high probability, is the pronounced incidence of heat waves, leading to an increase in urban heat islands. The problems associated with water and heat waves will affect the entire city, but the spatial expression of such risks and their impacts on households and individuals are closely related to the spatial patterns of vulnerability, social and socio-spatial inequality and therefore call for a direct nexus between climate change adaptation, urban land-use planning and risk management. Future housing policies must incorporate these elements and, in certain spatial contexts, so should future policies on water, energy and food security.

One factor that can limit the development of actions to address the impacts of climate change is the complex administrative structure in the region's urban areas (for example, the division of the urban continuum into different political and administrative territories) since overlapping responsibilities and possible political differences in a complex political setting can affect capacity for collaboration. Nonetheless, there are possibilities for overcoming such complexities, as shown through the development of the Climate Action Programme of Mexico City (PACCM), even though the programme only extends to the Federal District and not across the entire metropolitan area of Mexico City.

In all of the metropolitan areas steps are being taken to institutionalize the issue of climate change at the urban scale. Some cities, such as Santiago and Bogotá, have shown that it is possible to include adaptation in the existing institutional framework, with a view to benefiting as much as possible from existing activities, and on that basis to develop specific climate change adaptation measures. In other cases, the process began with the development of specific plans, which are later accompanied by legislative changes and the creation of specific laws on climate change, as in Mexico City and São Paulo.

Either way, the specific measures being taken are more closely aligned with mitigation rather than adaptation policy; and they tend to be more successful when linked directly with other urban or national political goals. This presents a great opportunity, as can be seen for example in the case of mitigation through the reduction of greenhouse gases, which has led to policies and measures to support energy efficiency, improve urban transport and reduce pollution caused by waste. Similarly, an adaptation policy can generate secondary benefits in terms of efficient use of water, healthier architecture and urban design and even the implementation of risk management systems. All of these elements of climate change adaptation also provide potential paths to a more sustainable city, irrespective of the uncertainties surrounding the expected changes in the city.

For the implementation of climate change policies it would be useful to follow up on the various processes and achievements in the different metropolitan areas of Latin America in order to evaluate the progress of the different developments and to learn from the most successful of them. Lessons can already be learned from the information gathered and summarized in this document and the representatives from the different cities have already begun to strengthen their ties. The hope is therefore that the contact and exchanges between cities will continue with a view to developing more specific and effective measures for climate change adaptation in all cities.

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Annex

Annex 1
List of external workshop participants

First workshop, 24-25 January 2011		
City	Name	Institution
Buenos Aires	Inés Camillioni	University of Buenos Aires
	Ana Murgida	University of Buenos Aires
São Paulo	Andrea Young	Population Studies Unit, UNICAMP
Lima	Elizabeth Silvestre	National Meteorology and Hydrology Service, Peru
	Eduardo Calvo	University of San Marcos, Lima
Bogotá	José Daniel Pabón	National University, Bogotá
	Andrea Lampis	University of Los Andes, Bogotá
	Patricia Romero Lankao	National Centre for Atmospheric Research
Santiago	James McPhee	University of Chile

Second workshop, 26-27 September 2011		
City	Name	Institution
Buenos Aires	Mónica Casanovas	Government of the Province of Buenos Aires
São Paulo	Ricardo Pereira Leite	Housing Department of the Prefecture of São Paulo
Lima	Ana Zucchetti	Environment Programme of the Regional Government of Lima
	Edén Atalaya	Territorial Management Programme of the Ministry of Housing, Construction and Sanitation of Peru
Bogotá	María Claudia García	IDEAM, Ministries of Environment, Housing, Territorial Development
México City	Óscar Vázquez Martínez	Environment Department of Mexico Federal District
	Andrés Flores Montalvo	Department of Climate Change Research, INE
Santiago	Rodrigo Robles	Government of the Metropolitan Region of Santiago
	Gonzalo León	Ministry of Environment of Chile

Third workshop, 11-13 June 2012		
City	Name	Institution
Mexico City	Iván Islas Cortés	National Institute of Ecology of Mexico
	Patricia Romero Lankao	National Centre for Atmospheric Research
Bogotá	José Daniel Pabón	National University de Colombia
	Gloria Narváez Tafur	District Environment Department of the Municipality of Bogotá
São Paulo	Diana Motta	Government of the state of São Paulo
	Margarete Amorim	Universidade Estadual Paulista Júlio de Mesquita Filho
Lima	Sofía Haydee Hidalgo	Metropolitan municipality of Lima

	Eduardo Calvo	Universidad Nacional Mayor de San Marcos
Buenos Aires	Mónica Casanovas	Government of the Province of Buenos Aires
	Inés Camilloni	University of Buenos Aires
Santiago	Jaime Rovira	Ministry of the Environment of Chile
	Osvaldo Aravena	Government of the Metropolitan Region of Santiago
	Rodrigo Robles	Government of the Metropolitan Region of Santiago

Annex 2
Programme of the first workshop: Adaptation to climate change: Characteristics and impacts in Latin American cities

1er Taller Red regional de aprendizaje
proyecto ClimaAdaptaciónSantiago (CAS)

Adaptación al cambio climático: características e impactos en ciudades de América Latina

24-25 de enero 2011

Salón Celso Furtado, CEPAL

Santiago de Chile

PROGRAMA

Lunes 24 de enero, 1er día de taller

09:30 – 09:45		Bienvenida a los participantes Joseluis Samaniego (UN-CEPAL), Kerstin Krellenberg (UFZ), Johannes Rehner (PUC)	
09:45 – 10:45	09:45 – 10:15	Presentación: Objetivos alcances del proyecto *Clima Adaptación Santiago* (Kerstin Krellenberg, UFZ)	
	10:15 – 10:45	Preguntas y discusión (Moderador: Ricardo Jordán, UN-CEPAL)	
10:45 – 11:15		*COFFEE BREAK*	
11:15 – 12:15	11:15 – 11:45	Presentación: Cambio climático en Santiago de Chile (James McPhee, Universidad de Chile)	
	11:45 – 12:15	Preguntas y discusión (Moderador: Ricardo Jordán, UN-CEPAL)	
12:15 - 13:15	Ciudad: Buenos Aires, Argentina Moderador: Ricardo Jordán (UN-CEPAL)		
	12:15 – 12:55	Cambio climático a nivel de ciudades metropolitanas de América Latina Inés Camilloni (Universidad de Buenos Aires, Argentina) (máx. 20 min.)	Principales impactos del cambio climático ante posibles escenarios Ana Murgida (Universidad de Buenos Aires, Argentina) (máx. 20 min.)
	12:55 – 13:15	Preguntas y discusión	

13:15 - 14:30	*ALMUERZO*		
14:30 – 16:30	Ciudad: Sao Paulo, Brasil. Moderadores: Sven Schaller/Kerstin Krellenberg (UFZ)		
	14:30 – 15:10	Cambio climático a nivel de ciudades metropolitanas de América Latina	Principales impactos del cambio climático ante posibles escenarios
		Andrea Young (Núcleo de Estudos de População UNICAMP, Brasil) (máx. 40 min.)	
	15:10 – 15:30	Preguntas y discusión	
	15:30 – 16:30	Discusión: Resumen interactivo de las características de las ciudades de Buenos Aires y Sao Paulo	

Martes 25 de enero, 2do día de taller			
09:00 – 10:00	Ciudad: Lima, Perú. Moderador: Ricardo Jordán (UN-CEPAL)		
	09:00 – 09:40	Cambio climático a nivel de ciudades metropolitanas de América Latina	Principales impactos del cambio climático ante posibles escenarios
		Elizabeth Silvestre (Servicio Nacional de Meteorología e Hidrología del Perú) (máx. 20 min.)	Eduardo Calvo (Universidad de San Marcos, Lima, Perú) (máx. 20 min.)
	09:40 – 10:00	Preguntas y discusión	
10:00 – 11:00	Ciudad: Bogotá, Colombia. Moderador: Ricardo Jordán (UN-CEPAL)		
	10:00 – 10:40	Cambio climático a nivel de ciudades metropolitanas de América Latina	Principales impactos del cambio climático ante posibles escenarios
		José Daniel Pabón (Universidad Nacional, Bogotá, Colombia) (máx. 20 min.)	Andrea Lampis (Universidad de Los Andes, Bogotá, Colombia; desde 2012 profesor asociado Universidad Nacional de Colombia) (máx. 20 min.)
	10:40 – 11:00	Preguntas y discusión	

11:00 – 11:30	*COFFEE BREAK*	
11:30 – 13:30	Ciudad: Ciudad de México, México Moderadores: Sven Schaller/Kerstin Krellenberg (UFZ)	
	Cambio climático a nivel de ciudades metropolitanas de América Latina	Principales impactos del cambio climático ante posibles escenarios
	11:30 – 12:10	Patricia Romero Lankao (National Center for Atmospheric Research, CO, EE.UU) (vía videoconferencia) (por confirmar) (máx. 40 min)
	12:10 – 12:30	Preguntas y discusión
	12:30 – 13:30	Discusión: Resumen interactivo de las características de las ciudades de Lima, Bogotá y México
13:30 – 14:30	*ALMUERZO*	
14:30 – 15:00	Resumen técnico: Resultados y conclusiones (Ricardo Jordán/Benjamín Infante, UN-ECLAC)	
15:00 – 16:30	Discusión: ¿Qué es lo que todavía no sabemos? ¿Qué necesitamos saber para elaborar un plan de adaptación? ¿Cuáles son las organizaciones aptas para invitar al segundo taller? Moderadores: Ricardo Jordán (UN-CEPAL) y Kerstin Krellenberg (UFZ)	
16:30 – 16:45	Cierre y pasos siguientes Ricardo Jordán (UN-CEPAL), Johannes Rehner (PUC), Kerstin Krellenberg (UFZ)	
16:45 – 17:00	COFFEE	

Annex 3
Programme for the second workshop: Adaptation to climate change: Plans and action in Latin American cities

2do Taller Red regional de aprendizaje
proyecto ClimaAdaptaciónSantiago (CAS)

Adaptación al cambio climático:
Planes y acciones en megaciudades de América Latina
26-27 de septiembre 2011
Salón Raúl Prebisch, CEPAL, Santiago de Chile

PROGRAMA
Lunes 26 de septiembre, 1er día de taller

09:30 – 09:50		Bienvenida a los participantes. Carlos de Miguel (ONU-CEPAL), Kerstin Krellenberg (UFZ)
09:50 – 11:00	09:50 10:30	Presentación de los participantes.
	10:30 11:00	Presentación: Introducción al proyecto *ClimaAdaptaciónSantiago*, resultados del 1er taller y objetivos del 2° taller. Kerstin Krellenberg (UFZ)
11:00 – 11:30	Café	
11:30 – 12:10	Ciudad: Santiago, Chile Moderador: Ricardo Jordán (ONU-CEPAL)	
	11:30 11:40	Presentación: Plan de adaptación a nivel nacional/subnacional. Gonzalo León (Ministerio del Medio Ambiente de Chile)
	11:40 11:50	Presentación: Plan de adaptación a nivel metropolitano. Rodrigo Robles (Unidad de Desarrollo Sustentable en Gobierno Regional Metropolitano de Santiago)
	11:50 12:10	Preguntas y resumen técnico.

	Ciudad: Buenos Aires, Argentina Moderador: Johannes Rehner (PUC)	
12:10 – 12:45	12:10 12:25	Presentación: Plan de adaptación a nivel nacional/subnacional. Mónica Casanovas (Representante en Cambio Climático de la Provincia de Buenos Aires)
	12:25 12:45	Preguntas y resumen técnico.
12:45 - 13:45	Almuerzo	
	Ciudad: Sao Paulo, Brasil Moderador: Kerstin Krellenberg (UFZ)	
14:00 – 14:35	14:00 14:15	Presentación: Plan de adaptación a nivel metropolitano. Ricardo Pereira Leite (Secretario de Vivienda de la prefeitura de Sao Paulo)
	14:15 14:35	Preguntas y resumen técnico.
	Ciudad: Lima, Perú Moderador: Ricardo Jordán (ONU-CEPAL)	
14:35 – 15:15	14:35 14:45	Presentación: Plan de adaptación a nivel nacional/subnacional. Edén Atalaya (Coordinadora de Gestión Institucional Programa de Gestión Territorial del Ministerio de Vivienda, Construcción y Saneamiento del Perú)
	14:45 14:55	Presentación: Plan de adaptación a nivel metropolitano. Ana Zucchetti (Gerente del Programa de Ambiente del Gobierno Regional de Lima)
	14:55 15:15	Preguntas y resumen técnico.
15:15 – 15:45	Café	

	Ciudad: Bogotá, Colombia Moderador: Kerstin Krellenberg (UFZ)	
15:45 – 16:20	15:45 16:00	Presentación: Plan de adaptación a nivel nacional/subnacional. María Claudia García (IDEAM, Ministerios de Ambiente, Vivienda, Desarrollo Territorial)
	16:00 16:20	Preguntas y resumen técnico.
	Ciudad: Ciudad de México, México Moderadores: Benjamín Infante (ONU-CEPAL)	
16:20 – 17:00	16:20 16:30	Presentación: Plan de adaptación a nivel nacional/subnacional. Andrés Flores Montalvo (Director de Investigación sobre Cambio Climático, INE)
	16:30 16:40	Presentación: Plan de adaptación a nivel metropolitano. Óscar Vázquez Martínez (Director de Cambio Climático, Secretaría de Medio Ambiente DF)
	16:40 17:00	Preguntas y resumen técnico.
17:00 – 18:00	Resumen del 1er día y adelanto del 2do día.	
20:00 -	Cena. Restaurant ‘El Parrón’	

PROGRAMA

Martes 27 de septiembre, 2do día de taller

	Taller: Procesos de elaboración e implementación de los planes /programas. <u>Moderadores:</u> Kerstin Krellenberg (UFZ), Ricardo Jordán (ONU-CEPAL)	
09:30 – 11:00	09:30 – 10:00	Diálogo por escrito.
	10:00 – 10:30	Priorización de temas.
	10:30 – 11:00	Presentación de los resultados en pleno.
11:00 – 11:30	Café	

	Taller: Discusión sobre las experiencias en las ciudades Moderadores: Kerstin Krellenberg (UFZ), Johannes Rehner (PUC)	
11:30 – 13:00	11:30 – 12:00	Clasificación de los temas para discutir.
	12:00 – 13:00	*Brainstorming* sobre las experiencies en las ciudades.
13:00 – 14:00	Almuerzo	
	Panel de discusión: Avanzando en la elaboración e implementación de las agendas de adaptación - ¿Qué soluciones existen? Moderadores: Benjamín Infante (ONU-CEPAL), Johannes Rehner (PUC)	
14:00 – 15:15	14:00 – 14:20	¿Qué podríamos aprender de las oportunidades y ventajas?
	14:20 – 14:50	¿Qué soluciones hay para los obstáculos y desafíos?
	14:50 – 15:15	¿Cuáles son los temas pendientes?
15:15 – 15:45	Café	
	Panel de discusión: Resultados y Conclusiones Moderador: Ricardo Jordán (ONU-CEPAL)	
15:45 – 16:45	15:45 – 16:15	Presentación: Resumen técnico sobre las lecciones aprendidas. Kerstin Krellenberg (UFZ), Johannes Rehner (PUC)
	16:15 – 16:45	Cierre y pasos siguientes Ricardo Jordán (ONU-CEPAL), Kerstin Krellenberg (UFZ)

Annex 4
Programme for the third workshop: Adaption to climate change: Connection between science and politics

3er Taller Red regional de aprendizaje
Proyecto ClimaAdaptaciónSantiago (CAS)

Adaptación al cambio climático en las ciudades de América Latina:
interfaz entre ciencia y política

11-13 de Junio 2012
Santiago de Chile

PROGRAMA

Lunes 11 de Junio, Evento público

Evento público: Más calor, menos lluvia: Santiago bajo el cambio climático. ¿Y las otras ciudades latinoamericanas?

Moderación: Kerstin Krellenberg (UFZ), Ricardo Jordán (ONU-CEPAL)

Lugar: Pontificia Universidad Católica de Chile, Centro de Extensión - Sala de Cine, Avda. Libertador Bernardo O'Higgins 340, Santiago

18:00 – 20:00

El proyecto ClimaAdaptaciónSantiago
Kerstin Krellenberg, Helmholtz Centre for Environmental Research – UFZ, Leipzig

Adaptación al cambio climático en la ciudad latinoamericana: ¿Por qué y cómo?
Patricia Romero Lankao, National Center for Atmospheric Research (NCAR), Boulder

Adaptación en la planificación urbana en Sao Paulo, Brasil - medidas concretas
Diana da Motta, Secretaría de Desarrollo Metropolitano, Gobierno del Estado de Sao Paulo

Cambio climático en Santiago de Chile - ¿qué pasa y qué tenemos que hacer?
Jonathan Barton, Pontificia Universidad Católica, Santiago de Chile

PROGRAMA

Martes 12 de junio, 1er día de taller

9:30 – 9:50	Bienvenida a los participantes e introducción al taller Ricardo Jordán (ONU-CEPAL), Kerstin Krellenberg (UFZ)	
9:50 – 10:10	Actividad participativa: Barómetro temático Moderación: Anke Schwarz (UFZ)	
10:10 – 12:00	Presentación de resultados y experiencias del proyecto CAS, Santiago	
	10:10 – 10.40	Presentación de los resultados claves del proyecto ClimaAdaptaciónSantiago (CAS) Kerstin Krellenberg (UFZ)
	Café	
	11:10 – 11:25	Experiencias del proceso participativo CAS: Las mesas redondas Jaime Rovira (Ministerio de Medio Ambiente, Santiago de Chile) y Rodrigo Robles (Gobierno Regional, Santiago de Chile)
	11:25 – 11:40	Implementación política del Plan de Adaptación en Santiago Osvaldo Aravena (Consejero Gobierno Regional, Santiago de Chile)
	11:40 – 12:00	Preguntas y comentarios
12:00 – 13:00	Presentación de los desafíos más importantes en Bogotá, Buenos Aires, Ciudad de México, Lima y Sao Paulo Moderación: Anke Schwarz (UFZ) y Johannes Rehner (PUC)	
13:00 – 14:00	Almuerzo	
14:00 – 16:15	Trabajo en equipo: Visiones – el futuro de las ciudades bajo el cambio climático	
	14:00 – 14:30	Introducción al trabajo en equipo, formación de los equipos Kerstin Krellenberg (UFZ), Johannes Rehner (PUC/ONU-CEPAL)
	14:30 – 16:15	Trabajo en equipo I: Visiones
16:15 – 16.40	Introducción de la carta de intención y adelanto al 2do día Ricardo Jordán (ONU-CEPAL), Kerstin Krellenberg (UFZ)	

PROGRAMA
Miércoles 13 de junio, 2do día de taller

9:30 – 9:45	Objetivos del 2do día Johannes Rehner (PUC), Kerstin Krellenberg (UFZ)	
9:45 – 10:15	Presentación de los resultados del Trabajo en equipo I: Visiones	
10:15 – 10:45	Café	
10:45 – 13:00	Trabajo en equipo II: Planes y medidas de adaptación y su implementación	
13:00 – 14:00	Almuerzo	
14:00 – 15:00	Presentación de resultados del trabajo en equipo II y resumen	
15:00 – 16:00	Panel de discusión: Hacia el futuro post-CAS, ¿Cómo organizar un futuro intercambio sobre adaptación urbana? Moderación: Kerstin Krellenberg (UFZ), José Javier Gómez (ONU-CEPAL)	
	15:00 – 15:30	Discusión ¿En cuales áreas de adaptación le interesa una futura cooperación?
	15:30 – 16:00	Firma de la carta de intención
16:00 – 16:30	Conclusiones y cierre Kerstin Krellenberg (UFZ), José Javier Gómez (ONU-CEPAL)	

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