Chapter 1
Introduction

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Abstract Urbanization has become one of the most omnipresent features of the twenty-first century world. More than half of the world's population lives and develops their activities in cities, and by 2050, this figure is expected to include two-thirds of people worldwide. These urban changes have created specific natural and social environments, including urban climates, not only in the large metropolis, but also in mid-sized cities. In this context, this chapter introduces the main urban, environmental, and climatic problems of Latin American cities. The modification of the local climate is characterized by a change of climate conditions, with higher temperatures, lower humidity and ventilation, atmospheric pollution, and poor environmental quality. In Latin American cities, these conditions have large geographic variations in terms of latitude (from 32°N to 56°S), altitude (from sea level to over 5,000 m), watershed, topography, and ocean influence, among other natural factors. Using the Urban Climate System Monteiro (Teoria e clima urbano. 16 USP/FFLCH thesis (Livre-docência), São Paulo, 1976) approach, the book is structured in three parts or subsystems: thermodynamic, physiochemical, and hydrometeorological subsystems. The focus is on the geographic dimensions of thermal comfort, air quality, and extreme events, and how, through planning and adaptation, proposals can be developed to cope with such challenges.

Keywords Urban growth · Socio-environmental inequality · Thermal comfort · Air quality · Hydrometeorological events · Urban climate system

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C. Henríquez, H. Romero (eds.), *Urban Climates in Latin America*,
https://doi.org/10.1007/978-3-319-97013-4_1

Urbanization has become one of the most omnipresent features of the twenty-first century world. More than half of the world's population lives in, and develops their activities in cities, and by 2050, this figure is expected to include two-thirds of people worldwide (United Nations 2014). Indeed, some authors speak about "planetary urbanization" (Brenner 2013, 2014; Brenner and Schmid 2011) or even the emergence of an "Anthropocene Age" (Crutzen 2005; Lewis and Maslin 2015; Steffen et al. 2011), to highlight the influence of human activity over the global urban environment. A complex situation is taking shape for urban suitability, and, given the projections, this situation could become even more critical in the coming years (Tebaldi et al. 2006).

The Latin America and the Caribbean region is not immune to this global trend; 79.5% of the population lives in cities (UN-Habitat 2011). The negative effects of urbanization are evident on all spatial scales: megacities, large cities, and medium-sized cities. However, in metropolises such as Mexico City, São Paulo, Buenos Aires, Lima, Bogotá or Santiago, urbanization presents very distinct features with respect to the hegemonic countries of the first world system. These include gigantism and uncontrolled growth of urban spaces, apparent disorder and dispersion, privatization of land and environmental components, socioenvironmental fragmentation, informal employment, markets and services and, as a result, impoverishment, exclusion, conflicts, violence, and pollution affect most of their societies (Pradilla and Márquez 2008). Latin American cities have experienced rapid urbanization over the past few decades and this has generated significant effects in socioeconomic and environmental terms. On the one hand, there is noticeable segregation and marginalization of the population, and on the other, there are places where wealth is concentrated and causes an "elitist" distribution of space. Consequently, according to the model proposed by Borsdorf (2000), cities are following a fragmented city pattern that represents transformations associated with social inequalities, symbolized by the unregulated distribution of residential areas, industrial zones, the location of shopping centers throughout the city, intra–extra urban highways, and by the presence of gated communities that protect the exclusive social sectors from "citizen insecurity," among other urban artifacts. It is also characterized by built area densification and gentrification in the city center, consolidation of slums on the periphery, and urban renewal programs in many locations. Another feature of this dynamic is that urban growth was not only caused by migratory pressure, but also by other driving forces such as socioeconomic status, generating a very segregated city (Henríquez 2014; Hidalgo et al. 2008).

The classic urban form of Latin American cities associated with the colonial style and the compact city is moving toward a fragmented and sprawling form. Some urban patterns, such as ribbon urbanization, are controlled by a massive and homogeneous displacement of the population toward the edges of the urban areas. The "leap frog" growth, linked to urban commuters in search of living in a gated community, such as a "country club," "*loteamentos fechados*," or "*parcelas de agrado*" is representative of several Latin American cities. This corresponds to spatially discontinuous peri-urban development, where the urban enclaves occupied by different social segments look for amenities that nature or rural spaces offer. At the same time, the *"tentacles"* pattern present in many cities shows horizontal growth from structured pathways, and is highly dependent on the use of a private car. All of these types of urban change have created specific natural and social environments, including urban climates, not only in the large metropolises, but also in mid-sized and smaller cities.

1.1 Urban Climates and the (Un)Sustainable Development of Latin American Cities

The creation of urban spaces reflects vital social needs, cultural adaptation to the fluctuations of nature, and aspirations based on popular consciousness where a common goal is to promote systems of knowledge and practices that often imitate forms that have been generated elsewhere, thus rejecting local or indigenous models. These societal objectives are intermediated and controlled in contemporary society by predominant political–economic systems on a global scale. In the case of Latin America, the predominant system has been based on the neoliberal doctrine. Among these premises, an important component is the separation and commodification of individual environmental elements, such as climate, land, water, and vegetation, and their interactions that are expressed throughout landscapes and territories. Privatization, another fundamental premise of this model, has led to the disappearance of a set of common goods and services, which include not only natural resources, but also previous social and cultural practices relating to territories and urban spaces (Romero and Vásquez 2006).

The components of the natural landscape (climate, water, land, biodiversity) and built systems (urbanizable land, housing, roads, urban highways, ports, water supply services, electricity and fuel, health and education, among others) have been largely commercialized and privatized – explicitly or tacitly – in many Latin American countries. Chile has been a pioneer in the implementation of this system for more than 40 years, covering all areas of social development, natural resources, territories, and places. Therefore, the experience of this country can be useful for comparing the environmental effects of recent urbanization processes and the current state of sustainability of urban spaces in this part of the world.

The urban environment has been a main protagonist in recent socio-economic transformations in the region. Urbanization and the consequent abandonment of rural areas, caused by the intensification, modernization, and automation of globalized monocultures, among many other factors, has involved a massive concentration of the national population in metropolises and cities. The main metropolises and some intermediate cities have received migrants within spaces characterized by their environmental fragility, high climatic variability, and the presence of significant natural threats. Droughts, intense and concentrated rains, floods, considerable atmospheric stability and the presence of a warm inversion layer that affects vertical movements of air (and the loss of its capacity for purification), and reduced ventilation are examples of natural processes that affect many urban environments in Latin American cities.

Rapid urbanization in Latin America has not been accompanied by the resources needed to undertake proper urban planning and management, which is necessary to supply local societies and places with the required services and environmental quality. As a result, irregular occupation of unsuitable sites for urbanization and the lack of concern and financial support invested in the provision of necessary facilities has meant that millions of new inhabitants have often endured difficult conditions of adaptation to their new habitats. Although Chile is currently one of the countries with the highest per capita incomes and ranks among the top performers in the human development index in the region (including the the lowest poverty figures), all Chilean cities continue to concentrate neighborhoods where poverty is linked to a lack of opportunities and infrastructure, and where higher levels of insecurity result from combined natural and socio-economic threats.

Latin American cities currently present an increasing spatial concentration of people, artifacts and processes that are simultaneously considered to be indicators of socioeconomic development and environmental degradation. Satisfying the demand for goods and services of a heterogeneous society that essentially shares its urban condition – with the challenges of fulfilling housing needs, improving quality of life, an increasing amount and better quality of urban equipment, and the existence of a healthy and safe environment – has become increasingly difficult to achieve with the social, economic, and cultural resources available.

Additionally, opening countries to the global economy and increased trade flows has meant the consolidation of an uneven social situation between growing high-income social groups that demand an unlimited quantity and quality of spaces, goods, and services, and those middle and lower-income groups trying to satisfy their basic needs. As a result, Latin American cities, particularly the large and medium-sized cities, reveal a clear division between an uncontrolled and growing presence of multiple environmentally negative externalities caused by excessive consumption of goods and services concentrated in areas where the richer people live, and the lack of them or their inefficient distribution among middle class and lower class inhabitants that occupy most of the urban environment (Romero 2000).

The need to make space for urban sprawl and to facilitate the transformation of natural and rural spaces into urban areas is one of the reasons why Latin American cities, are constantly expanding without a strategic environmental assessment of its growth areas or environmental impact assessment of large urban projects. These assessments should consider both the improvement and conservation of source areas of clean air, water, and environmental services, in addition to the maintenance of land cover and uses, and urban design that favors the control of temperatures, adequate atmospheric humidity, and the persistence of ventilation flows that contribute to air and climate quality.

The loss of quality of urban climates has been a prevalent matter of concern in most Latin American research, and academic contributions on this topic have multiplied in recent decades. Nevertheless, no specific strategies or programs are known that explicitly attempt to reverse current situations, reflected in plans, programs, and urban development projects. Scientific contributions on urban climate characteristics and its quality do not seem to affect public decision-making to any degree; they are rarely taken into account in the adoption of new plans or in the recognition of social demands. Decision-making processes are almost always resolved as a function of social urgency and immediate economic returns.

For example, the availability of green areas, which is fundamental in the control of temperature, humidity, winds, air quality and quality of life in cities, depends mainly on the existence of private gardens inside or around homes and buildings, or is related to the socio-economic status of neighborhoods in which they exist. Only richer neighborhoods have sufficient private or public resources to generate and maintain squares, parks, and streets with vegetation. Conversely, if the inhabitants of the neighborhood are poor, then green areas rarely exist or are present in only small areas. As a result, climatic features produced by green areas represent levels of socio-environmental injustice within Latin American cities.

Poorer urban inhabitants in Latin America are not only exposed to environmental deficits, but also to climatic extremes on a larger scale, because they are located in areas affected by constant natural hazards, or they receive flows of polluted air, domestic and toxic waste and water, which in some cases, come from richer areas to their residential areas.

On the other hand, ecosystem services and environmental amenities provided by vegetation to produce comfortable urban climates and to prevent and control hazards such as heat and cold waves, flash floods and inundations, tend to be concentrated in the richer zones of the city (Romero et al. 2010). Some common environmental services such as regulation of temperature, availability of shade, air moisture from evapotranspiration, flood control, conservation of biodiversity, and the strength of cultural values, such as peacefulness and beauty, do not mostly depend on social and collective projects in public spaces, but on solutions controlled primarily by the existence of related family and municipal economic resources.

Urban areas that suffer most from the effects of so-called natural disasters or extreme dangerous events (such as storms, floods, waterlogging, gales, heat waves or cold snaps, and concentration of atmospheric pollutants) are mainly located in areas where the population with the fewest resources resides. These are places that have steep slopes, are particularly affected by debris flows, or are situated in closed topographic depressions or along river beds, and in zones under thermal inversion layers therefore with greater atmospheric stability and pollutant potential. Sometimes, they are in proximity of forests or plantations, exposed to wildfires or pollution caused by the excessive use of agrochemicals. Many urban settlements are near toxic and hazardous industries, along roads with greater traffic pollution, in the proximity of wetlands, coastal swells, or domestic and industrial waste deposits. Some of these places are so-called "sacrifice zones," because not only do they have the worst spatially concentrated environmental conditions, they also receive waste from the entire city, without compensation.

The growth of Latin American cities also follows different social, economic and cultural patterns, which have a significant influence on the quality of urban environments and climates. Higher income families settle in suburbanized zones located at increasing distances from city centers, polluted zones, and hazardous areas. This favors the generation of polycentrism where new nodes for goods and services are provided, including construction, commerce, recreation, health, and education, but which degrade previously pristine and natural landscapes. New urban heat islands and air pollution concentrations (caused by high-rise building, numerous private cars, fertilized gardens, and domestic heating systems) become a characteristic climatic feature of these recently incorporated landscapes. On the other hand, lower-income inhabitants, including immigrants in search of lower land and residential costs, are forced to occupy degraded, abandoned, central neighborhood districts or reside in spaces at increasing distances from sources of goods, services, and work.

Each of the different social groups introduces land use and cover changes without corresponding socio-environmental assessments. The outcomes are the creation and transformation of urban climate characteristics and quality. Indeed, in the case of Santiago de Chile, higher income sectors that are increasingly located at more distant places from city centers not only devastate natural or rural landscapes, but also require private transport and the provision of higher-cost and segregated good and services. Additionally, the large number of trips and distances needed for travel produce adverse environmental effects such as imperviousness and air pollution. These environmental costs transfer to the rest of the population as social costs. Sometimes, and when faced with evidence for environmental deterioration, the recovery of natural areas through the installation of parks or green corridors not only involve high economic costs expenditure (and therefore are restricted to rich neighborhoods), but also do not restore the conditions of the original ecosystem.

The absence of environmental urban planning, regulation, management and assessment in general, and particularly in terms of urban features associated with the social heterogeneity and uneven development of urbanization, results in a complex and dynamic mosaic of urban landscapes and climates that is difficult to understand. An infinite multiplicity of specific areal, point-specific or linear features complicates the study of urban climates with the public information available. Few studies show the heat and cold islands, fragments of vegetation cover, the predominance of neighborhoods without significant green areas, nuclei and corridors that generate pollutants, and the diversity of densities and types of construction. This makes it difficult to generalize spatial and temporal patterns of urban climates in Latin American cities. Urban climate seems to be an archipelago of varied temperature, humidity, and ventilation features instead of a set of modellable landscapes. Comparison between surface temperatures obtained from satellite imagery and meteorological data captured in conventional stations, urban plots, and transect measurements across cities have shown a lack of correspondence. Point-specific data are clearly influenced by land use and cover that surround, or are contained in the monitoring sites. Synoptic meteorological conditions and the natural matrix where cities are located introduce significant variations in daily and even hourly records. Limited resources, the absence of standardized procedures, and the unresourcing of the public institutions in charge of urban climates are some of the limitations that explain the lack of importance of this issue in Latin America, where nearly 80% of the population live in cities.

Effective planning for the negative effects of global and local climate changes on urban societies and the need to mitigate and adapt to them, is constrained by the scarce information and knowledge available to the general public and decision-makers in particular. Consequently, there is a lack of political support to implement concrete measures. A large proportion of urban dwellers permanently suffer from a loss of climatic quality in their daily life and an increasing exposure to the risk of disasters. Some of this loss is – in the generation of permanent heat or cold urban islands in boundaries layer climates, for example – is due to new urban development processes that affect their neighbourhoods by altering urban climatic conditions. At the canopy layer, urban design and the material insulation of buildings tend to be precarious in climatic terms for most of the inhabitants. In the case of Chile, practically the same type of social housing extends several thousand kilometers from the arid desert in the north to the glacial weather in the south, or from the coast to the Andes mountain highlands. Public policies have not been able to promote and sustain relevant urban climate transformations on a local scale that translate the mitigation and adaption commitments assumed internationally. It seems that political indifference, cultural resistance, social and economic priorities, and the lack of dedicated institutions prevent the planning and management of sustainable urban spaces in Latin America. At best, they are restricted to case studies, isolated in space and often ephemeral over time.

The development of urban climatology is increasingly important in Latin American countries. The limited available scientific and local knowledge has not mustered the strength to change the current situation. There are only a few groups of researchers within universities who must fight for survival with little social and institutional support. Accumulated and disseminated knowledge seems to be neither sufficient nor appropriate for societal and decision-maker understanding. Urban management continues to be held ransom to social, economic, and political urgency. One of the challenges is to develop a permanent dialogue between social actors and stakeholders so that climate issues appear in public discussion on a daily basis and not only in the face of extreme events or disasters when nature is mentioned as being responsible. Scientific, social, political, human, and ethical responsibilities have not been adopted by most social actors.

1.2 The Construction of the Urban Climate in Latin American Cities

Currently, the city is recognized as a complex ecosystem able to modify the local climate, essentially by the urban heat islands (UHI) effect (Douglas 1983; Oke 1987) and affect living conditions. This corresponds to an inadvertent effect of climate transformation from the natural landscape to the anthropic environment, dominated by a substitution of natural soils to different types of impervious surfaces with a greater heat capacity and lower reflexivity, that produce an increase in air temperature and a decrease in air humidity and local winds (Oke 1987). Other aspects involved in urban climate dynamics are related to heat, gases, and particles generated by human activities, which alter the energy balance and atmospheric compositions (Moreno 1998).

The modification of the local climate is characterized by a change of climate conditions, with higher temperatures, lower humidity and ventilation, atmospheric pollution, and poor environmental quality. In Latin American cities, these conditions have large geographic variations in terms of latitude (from 32°N to 56°S), altitude (from sea level to over 5,000 m), watershed, topography, and ocean influence, among other natural factors. In fact, the dynamics of urban centers are intimately linked to geography. For example, latitude determines a city's need for more or less energy to run air-conditioning and heating systems within its buildings, industries, and houses (UN-Habitat 2011). Many cities exhibit intense UHIs associated with their topological position, a fairly closed watershed or by the presence of a thermal inversion layer.

The rapid urbanization process of Latin American cities, in terms of either the built-up area or the number of urban inhabitants, has contributed to important climate and environmental changes. Air pollution, thermal discomfort, health problems, natural events, and climate change are increasingly relevant aspects of urban life. This requires a myriad of viewpoints to understand the urban climate.

The atmospheric pollution produced by industrial emissions and different types of transportation has transformed into one of the main problems for the environmental management of urban areas. According to the Clean Air Institute in Latin America and the Caribbean, at least 100 million people are exposed to air pollution above the limits recommended by the World Health Organization. The report warns that, of the 16 cities that measured PM10 concentrations in 2011, all exceeded the levels recommended by the WHO, and 9 of them exceeded the annual European Union standard (Green and Sánchez 2013). Cities such as Mexico City, Bogotá, and Santiago are exposed to high levels of air pollutants (particularly PM10), affecting the health of all local populations (Romero-Lankao et al. 2013). In Santiago, a direct relationship has been found between the distribution of UHI and the concentration of air pollution in poorer areas of the city on days with the worst air quality conditions (Romero et al. 2010).

Besides the increase in these types of pollutants, the use of wood-burning fuel for cooking and heating residences play a relevant role in the degradation of indoor air quality, especially in the fall and winter. Chilean cities such as Chillán, Temuco, and Coyhaique register high levels of particulate matter linked to wood-burning. At the same time, the pollutants act as neurotoxic compounds, which increase in locations that have a high level of traffic. For example, primary schools located near the street and children exposed to this pollution are associated with worse school performance and lesser cognitive development. For these reasons, some authors (Capel 2016) have named this situation an "airpocalypse", revealing environmental injustice in urban areas and an urgent need to generate social awareness.

1.3 Book Structure: The Approach of the Urban Climate System

To understand Latin American urban climates, it is necessary to take into consideration the location, topology, and position of cities in large-scale frameworks, such as climatic regions, topographical scenarios, and watersheds.

In the case of some large Latin American cities located in the Andes, there is a strong dependence on the city life support system of water accumulated in the Andean mountains. This is also the case for some of the other cities in South America, such as Santiago, Lima, Quito, and Bogotá. Atlantic cities, on the other hand, are heavily dependent on the performance of topoclimates developed along coastal and inland ranges, such as the case of the Mata Atlantica and "sierras" throughout Brazil.

In this context, a challenge in studying the urban climate is to strengthen and promote a conceptual and theoretical integration of Latin American researchers in urban climatology. From a historical point of view, one of the most highlighted studies of urban climate in Latin America is the Brazilian "Monterian" geographic approach. Carlos Augusto Monteiro (1976) based his work on the studies of Max Sorre and proposed, in his PhD thesis, the Urban Climate System (UCS) as a theoretical–empirical framework for the study of urban climates.

The author proposes that UCS organization must contemplate three subsystems mediated by channels of human perception:

- Thermodynamic/thermic comfort: includes the thermodynamic component of the system, which, in its relationships, is expressed through heat, ventilation, and humidity within basic references belonging to this concept
- Physicochemical/air quality: composed of elements inherent to the impacts of emissions and concentrations of atmospheric pollutants within the urban environment
- Hydrometeorological/impact media: grouped into all forms including water (rain, snow, fog), mechanical (tornados) and electric (storms) that have, sometimes, manifestations of intensity that can have an impact on the life of the city by disturbing circulation and services

These three elements of climate are highly transformed within cities and have helped in structuring this book. For each of them, the corresponding problems are identified and addressed through specific phenomena such as: UHIs, urban cool islands, temperature discomfort, thermal stress, flooding, thermal inversion, air pollution, among others (Mendonça 2015). For example, this approach has been applied in Brazilian cities such as the city of Dourados (dos Santos and da Silva 2014). Other relevant contributors to the study of urban climates in Latin America come from Mexico, Argentina, and Chile, including authors such as Jauregui, Mikkan, and Romero. In this context, Chapters 2 and 10 of the book address some theoretical topics of the study of climate in Latin America.

The occurrence of heat and cold waves is a frequent disturbance in Latin American cities. In many tropical and subtropical cities, heat waves are becoming not only an increasing feature of climatic discomfort (see Chaps. 5 and 6), but also a source of disease (see the example of dengue in the Chap. 12) and wider health impacts (Chap. 11 for a Chilean case). The continental shape of South America, with a straight Southern cone, and the archipelagic condition of Central America and the Caribbean, partly moderates the accumulation of heat due to oceanic and coastal ventilation. The topological and topographical location of Latin American cities, especially on coastal zones and riverbeds, is a source of uncertain climatic, safety, and air quality concerns. Chapter 3 reviews the cases of Guayaquil, Lima, Antofagasta, and Valparaíso along the coast of the Pacific Ocean.

In many cities, the population has been confronted with urban sprawl, unscrupulous land use and cover changes, and the presence of UHIs, which are increasing thermal discomfort levels (see Chaps. 5, 6 and 10). It can be assumed that many people do not live under viable climatic conditions, while some inhabitants are displaced to areas where climatic conditions are better and more secure. However, this is not a clear goal in most urban planning and policies, urban design and land use programs and projects. Economic reasons and the subordination of nature and ecology to other social and political priorities explain the current situation, where most of the urban inhabitants have the lowest levels of quality of life, and are relatively poor and excluded, and are permanently threatened by hazards, insecurity, and a lack of institutions to manage their growth and urbanization processes effectively.

The founding of many Latin American cities in the middle or lower position of river basins, or in the foothills of mountain systems, is mainly explained by the water supply, and the need to discharge natural wastewater for protective purposes. Today, it is clear that these geographic factors cannot adequately support large numbers of people, dwellings, vehicles, industries, and other sources of pollution. In addition to such topographical constraints, adverse features, such as UHIs, humidity islands, and ventilation islands, are severely compromising climate and air quality and, as a consequence, the quality of life of an increasing population. Most Latin American urban inhabitants live with challenging local climates and are located in some of the most polluted cities on a global scale (Mexico City, Bogotá, Quito, Sao Paulo, Santiago) (see Chaps. 7 and 8). This requires not only pervasive and immediate improvements, but also available scientific knowledge to incorporate climate change, climate quality, climate comfort, and climate justice in urban and regional planning and management (see Chap. 9).

The occurrence of many extreme events such as droughts, floods, and waterlogging, greatly increases the vulnerability of urban spaces in all Latin American cities. Although in tropical cities, hurricanes and large storms are frequent natural threats and permanent sources of risk (see Chap. 10), droughts, floods, and waterlogging continuously affect cities located in subtropical latitudes and arid lands across the region. Consequently, a relevant number of disasters occur every year, which cause major damage in material goods and services, increased morbidity and mortality (see Chap. 11).

Until recently, the integration of urban climate in urban planning, and green infrastructures has have barely been taken into account. Furthermore, few cases have used climate and air quality as an indicator of quality of life. Consequently, there are few proposals to improve climate quality and to increase climate justice as part of socio-economic equity programs within the cities. Urban planning, urban design, and land use allocation affect urban climate dynamics and patterns at different atmospheric layers across three spatial scales: the urban boundary layer, the urban canopy layer, and the microclimate scale (Oke 1987); these dynamics include the UHI effect, cold and fresh air production, and drainage areas. On a local and micro scale, local climate zones (LCZ) (Stewart and Oke 2012) and urban canyons (Oke 1981) have been used for the analysis and modeling of climate in an international context, and the challenges is to apply these more widely in Latin American cities (see Chap. 4).

One relevant feature on this scale is the study of thermal comfort (TC). TC is defined as a mental condition that indicates satisfaction with environmental thermal conditions. From an environmental perspective, the study of TC has focused on the construction of indices and models that integrate climatic variables. However, multiple studies have highlighted the importance of conducting this type of research using additional variables for analysis, such as physiological status (thermo-regulation and metabolism) and perceptions, in addition to the attributes of urban space, since these are all influential (Nikolopoulou and Steemers 2003; Vanos et al. 2010). Even some relationships between violence and high temperatures in urban area (Pereira et al. 2016) have been developed, with applications. In some European cities, e.g. in Greece, Switzerland, and the UK. However, few experiences have been applied to Latin American cities (see Chaps. 5 and 6).

A last challenge is that of climate change and its relationship with urban scale. The effect of climate change on urban centers is clear, especially through the phenomenon of the UHI (see Chap. 2). Alongside rapid urban growth, climate change is already a fact. Consequently, many cities are highly vulnerable to its impacts (OECD 2010) and at the same time, are the leading source of greenhouse emissions (Mills 2007). Despite Latin American cities having little overall contribution on a global scale, they are highly vulnerable to the impacts of climate change. Tropical cyclones, floods, droughts and heatwaves are increasingly frequent events and have a great influence on the level of risk. According to a CAF report on the Vulnerability Index to climate change in South America it is Paraguay and Bolivia that reveal the highest vulnerability risks. Also, the capital cities in the region show significant vulnerability to climate change, with 48% categorized being at "extreme risk." The highest levels of vulnerability in urban areas are not concentrated in the region's megacities, but in medium-sized cities (Mapplecroft 2014).

Currently, research and public strategies that address urban adaptation plans are being applied in several countries to face climate change. In this regard, the study by Jean-Jacques Terrin (2015) generates interesting proposals for addressing the impacts of UHIs in several European cities, which should be expanded to Latin American cities. In this vein, see the examples in Chaps. 13, 14, and 15.

A relevant example of a natural risk management plan is the case of the city of Manizales, Colombia. The plan includes management areas that are directly related to the prevention of, and recovery from natural hazards, and are mainly related to landslides caused by heavy rains, in addition to incorporating the Territorial Land Use Plan (POTs in Spanish) as a fundamental axis in risk management. The "Guardians of the Slope" program stands out, which seeks to reinforce a culture of risk prevention by understanding the threat and the provision of tools to manage it, and the recognition of women as a central part of the monitoring program (Londoño 2003; PREDECAN 2009).

Some Latin American metropolises have received financial support to implement adaptation or resilience plans from international agencies such as the Helmholtz Centre for Environmental Research – UFZ or the Rockefeller Foundation (100 Resilient Cities), but there are few contributions from a Latin American regional base. As previously mentioned, the lack of basic knowledge is one of the main obstacles. This produces a paradox as the countries and cities that have less information when facing the most negative impacts of climate change are the most vulnerable.

In this context, the main goal of this book is to generate, disseminate, and discuss knowledge about urban climate topics in Latin American cities, and to increase the understanding of its relationships with other dimensions using an inter- and multidisciplinary approach. In this sense, the book expands upon the Monteiro (1976) approach and intends to bring examples of Latin American and, more specifically, South American cities, to an international arena of urban climate research.

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