

**UNIVERSITÀ DEGLI STUDI DI FIRENZE DOTTORATO DI RICERCA IN
PROGETTAZIONE URBANISTICA E TERRITORIALE**
Cycle XXXI

CITIES AND CLIMATE CHANGE:

Urban Projects in Latin-American cities and their role in climate change mitigation.

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April 17 / 2019

Acknowledgements

I would like to thank all of those who directly or indirectly helped me through my PhD journey in the University of Florence. It would never have been possible to achieve my research without the support and encouragement of many people and institutions.

I am grateful to my supervisor Professor Raffaele Paloscia who advised, supported and oriented me during my studies and who also has a special interest for Latin American countries' development. His commitment with the southern countries has been invaluable in my research and the quest of understanding and learning from them has been a great motivation for me.

I am also grateful to all the members of my family, especially my wife and her unconditional support and my children who always wondered by how long it would take to finish the PhD, living with the uncertainty of not knowing when they would go back to Chile but on the contrary wondering how long this Italian experience would last because they are already regretting it ending.

Various institutions have made this PhD possible, above all the Universidad Católica del Norte in Chile, my alma mater and sponsor, where I am a lecturer. My colleagues and superiors trusted in me to make the most of these four years of PhD with expectations and even with sacrifices. I am also grateful to Joaquin Sabatè for his wise advice and Clare Dickson, for her help with my English.

I cannot forget the Chilean Ministry of Education who gave me a grant through CONICYT PAI/INDUSTRIA 79090016.

I appreciate all the academics, administrators, colleagues and friends in the University of Florence and people that helped with generosity with words, advice, experiences and also the Italian community where I live in Cantiano, who opened their arms to kindly welcome all my family members.

Abstract

This research addresses the relationship between cities and climate change, specifically how urban projects can help to mitigate climate change in the context of Latin American cities.

It is argued that some urban projects can be transformed into a new generation of projects aimed at mitigating climate change by avoiding GHG emissions into the atmosphere with mobility and urban regeneration projects, and mitigation projects to diminish the risk of natural events, with reforestation, creation of parks, green corridors, and banks and shores of rivers and lakes.

In order to be successful, these urban projects must comply with several requirements, such as being incorporated into long-term urban planning, having a governance model that facilitates the necessary changes with a strong leadership of the mayors, an institute of urbanism or similar to build the projects, and top down and bottom up citizen participation at all levels.

The cities of Curitiba in Brazil and Medellin in Colombia are taken as case studies. The research concludes that several projects on an urban scale have been implemented in recent years and are enabling to mitigate climate change.

These projects were born with other objectives, responding to social, environmental and economic problems, but over time they have been integrated into the new challenges for cities in the face of climate change.

Although these projects are unique, they have been developed in particular historical contexts where the figure of the mayors has been fundamental for the achievement of the objectives. Therefore, the cases cannot be replicated exactly in other cities, but lessons can be extracted from the experiences to be able to implement similar actions and projects, considering the particularity of the geographical, cultural and social context of each city.

Keywords: Climate change; Latin America cities; mitigation actions; urban planning risk; mitigation urban projects.

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Acronyms and Abbreviations

APA	Areas de Protección ambiental, Curitiba
APPUC	Advice research in urban planning for Curitiba
BRT	Bus Rapid Transport
CDM	Clean Development Mechanism
CEPAL	Comisión Económica Para América Latina y el Caribe
CH ₄	Methane
CIAM	International Congresses of Modern Architecture
CO ₂	Carbon dioxide
CO ₂ eq	Carbon dioxide equivalent
CODEPAR	Company of development of the Parana river, Curitiba
COP	Conference of the Parties
CTS	Curitiba Transport System
C40	Cities Climate Leadership Group
EDU	Urban Development Enterprise
EDUVA	Urban development company for the Aburra Valley, Medellin
EC	European Commission
ETMVA	Public of Massive Transport Corporation of Aburra Valley, Medellin
ETSAB	Escuela Técnica Superior de Arquitectura de Barcelona
F-gases	Fluorinated gases
FM	Frequency modulation
GDP	Gross domestic product
GHG	Green House Gases
GUI	Green urban infrastructure
GUP	Great Urban Project
HFCs	Hydrofluorocarbons
IADB	Inter-American Development Bank
IBA	Internationales Bauausstellung Berlin
IBGE	Instituto Brasileiro de Geografia e Estatística
ICLEI	Council for Local Environmental Initiatives

ICV	Índice de Calidad de Vida
ITDP	Institute for transportation and development policy
IP	Integrated Planning
IPCC	Intergovernmental Panel on Climate Change
IPPUC	Institute of research and urban planning of Curitiba
IUP	Integral Urban Planning
JAC	Community action board
JCR	Journal Citation Reports
LAC	Latin America and the Caribbean
LEDS	Lights emitting diode
LRT	Light rail transit
NASA	National Aeronautics and Space Administration
NGO	Non-governmental organization
N ₂ O	Nitrous Oxide
OECD	Organization for Economic Cooperation and development
PDU	Urban Development Plan
PDUM	Urban Development Plan of Medellin
PEM	Medellin Strategic Plan 2015
PFCs	Perfluorinated chemicals
PM ₁₀	Particulate Matter of 10 Microns
POT	Plan de ordenamiento territorial
PPP	Purchasing power parity
PRC	Popular Republic of China
PRIMED	Programa integral de mejoramiento de barrios subnormales, Medellin
REDD	Reducing Emissions from Deforestation and Forest Degradation
RIT	Integrated Transit Network
RMC	Curitiba Metropolitan area
SF ₆	Sulphur Hexafluoride
SLCP	Short lived climate pollution
SMMA	Secretaria Municipal do Meio Ambiente Curitiba
SsLD	Self-sustainable local Development
SUP	Strategic Urban Project
TOD	Transport oriented development

UDP	Urban Development Project
UN	United Nations
UNCHS	United Nations Centre for Human Settlements
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	United Nations Human Settlements Programme
UNISDR	United Nations International Strategy for Disaster Reduction
USD	United States dollar
WHO	World Health Organization
WWII	World War II

Introduction

Climate change is one of the most challenging problems of humanity. Since the Rio 1992 and Paris 2016 agreements, countries endeavour to reduce greenhouse gas emissions to invert the trend of global warming. NASA's Goddard Institute for Space Studies reveals that the Earth's surface temperature increased 0.8°C since the last century and two thirds largely of this growth can be attributed to the time period since 1975. Cities are largely to blame for this situation (Carter et al., 2015). Some authors have indicated that:

“In 2015, the global population reached 7.3 billion with an increase of about 1 billion in the last twelve years alone. According to the United Nations, the proportion of the population living in urban areas is expected to increase from 54% to 66% by 2050. This proportion of urban inhabitants is even greater in Latin America and the Caribbean, where approximately 80% of the population already resides in urban areas” (Reynolds, Escobedo, Clerici, & Zea-Camaño, 2017).

According to Magnaghi (2005) it is estimated that 62% of the world's population will live in metropolitan centres or megalopolises by the end of the century. All these urban areas are degrading the environmental, social, cultural and political identities of dwellers.

While the world's urban population in 2016 represents 54%, for the Latin America region it is 83.3%, higher even than North America (81.6%) and Europe (73.6%) and for 2030, United Nations estimates that the world's urban population will increase to 60%, and Latin America's countries will continue to lead these statistics with 86%.

In addition, large cities are one of the features of the region; in 2016 five of 31 world megacities (with more than 10 million of inhabitants) were located in Latin America, such as Mexico City, São Paulo, Rio de Janeiro, Buenos Aires and Lima and by 2030 Bogota will join the group of megacities (United Nations, 2014).

Mitigation and adaptation¹ are the two main responses developed to fight against climate change for cities. Mitigation strategies are oriented to reduce greenhouse gas emissions and are mainly focused on waste treatment projects, alternative generation of energy and public transport on an urban scale. In the last decade, some examples to mitigate climate change have emerged, such as the projects of Dongtan eco-city in China and Masdar in the United Arab Emirates. These new cities were designed and planned with zero gas emissions but some authors do not believe this is possible on an theoretic level (Premalatha, Tauseef, Abbasi, & Abbasi, 2013).

Although the urban climate mitigation strategy proposed by these projects is mainly characterized by the use of high tech, where technological development in urban sustainability becomes urban technology, in the case of Masdar for example, the final result is an elitist model of eco-city projects, and theses “ecological enclaves, will be the utopia of the few and the dystopia of the many” (Cugurullo, 2016). On the contrary, cities like Freiburg and Graz have incorporated participative strategies and urban regeneration methods in planning and projects of mitigation (Späth & Rohracher, 2010) and similar initiatives can be found in Ghent, Belgium (Devolder, Block, Devolder, & Block, 2015) and in New York and Rotterdam (Camaioni, D’Onofrio, & Trusiani, 2017)

In the literature of mitigation actions, scholars have mainly been attending to areas such as energy efficiency, waste management, water treatment and transportation, neglecting the importance of the urban scale. On the other hand, more recently new topics have been incorporated in the analysis of mitigation actions through human settlements, building constructions and urban planning. However, this recent literature is limited to empirical cases in developed countries (especially in Europe) and cases of countries in the south with higher concentrations of urban population and managing mitigation strategies are ignored (Seto et al., 2014).

¹ The second response to fight climate change is adaptation strategy which means adjusting the natural or human systems to respond to the real or expected climatic effects that may cause damage in inhabited areas (Klein, 2007). This strategy is implemented through major infrastructural projects, carried out on a regional scale, for example, barriers to avoid flooding caused by high tides and rising sea levels and the reforestation of eroded areas subjected to rains that can cause landslides.

In effect, several Latin American cities are conducting mitigation projects with heterogeneous actions such as waste treatment, energy supply, public transportation, urban planning, building activities and land use. Also, many transport projects carried out are being considered within the mitigation strategies, as is the case of Medellín, Bogota, Buenos Aires, Curitiba, Santiago and Ciudad de Mexico City.

At the same time they are “main contributor to GHG emissions in the region’s cities, which means the projects to improve urban transport include implicitly or explicitly an environmental component” (Rodriguez, 2015).

Nonetheless they do not delve into the impacts that are currently occurring within cities or how these projects are serving as an impetus to develop urban regeneration strategies in central and peripheral areas. In this geographical zone, performance measures of the ecological impact of projects in cities are insufficient and little is said about the performance of mitigation. The indicators proposed in literature are very general and broad and only facilitate the cities’ ranking for comparison purposes.

The scale of analysis used is only for cities and a deep review in project scale is neglected. Thus, this research intends to deepen the knowledge of urban projects oriented to mitigating the climate change effects in large sized cities of Latin America. Therefore, my research question is:

How can mitigation urban projects contribute to reduce the climate change in Latin American cities?

The research objectives are to:

- Describe the relationship between cities and climate change.
- Create an integrative definition for mitigation urban project.
- Distinguish the main features of urban projects for climate change mitigation in Latin American cities.
- Identify the key conditions that enable the implementation of mitigation urban projects in Latin American cities.

This research is organized in five chapters as shown in Figure 1 and the methodological design is described in Figure 2.

The first chapter is dedicated to understanding the relationship between cities and climate change in a general perspective. In this chapter, risks that cities are experiencing in the climate change scenario are presented. Climate actions are introduced in terms of mitigation and adaptation possibilities. A special consideration is made in relation to the Latin American context.

The second chapter develops the urban planning and urban projects related to climate change mitigation. Urban planning and modern urbanism are described, then governance and urban institutes for climate change actions are summarized. In this chapter, first historical features about urban projects in Europe are treated and in a second moment the urban projects in Latin America are illustrated.

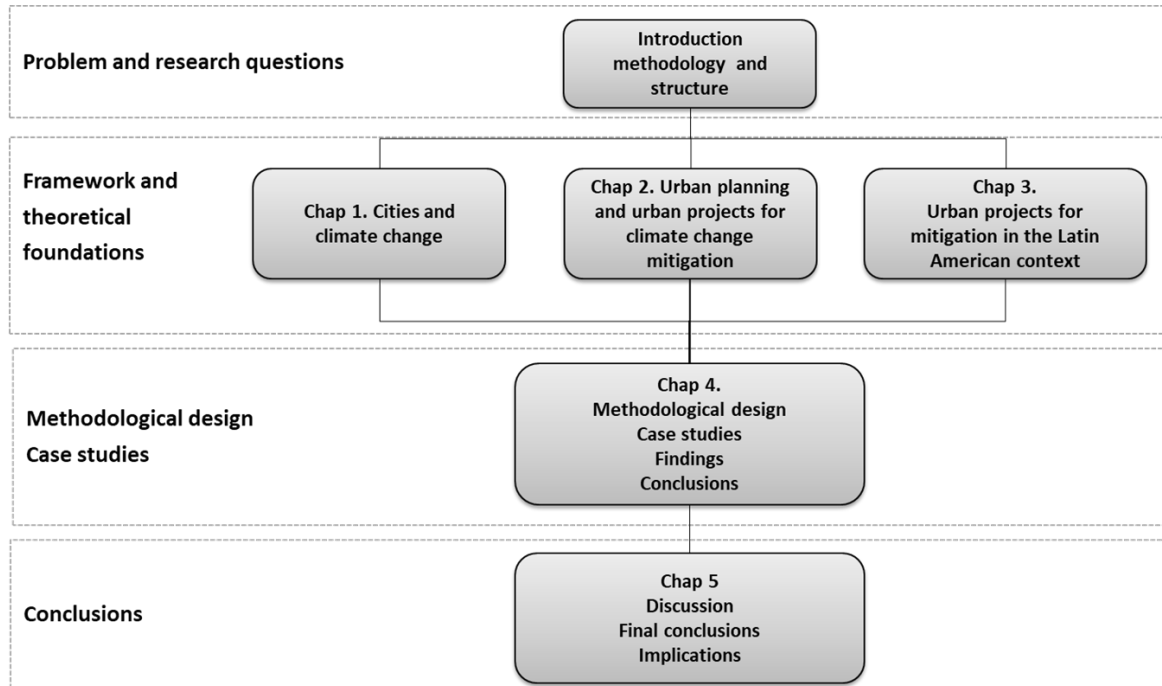
The third chapter centres the attention on urban projects for mitigation in the Latin American context, through the review of public transport projects and urban regeneration strategy as well as green urban infrastructure for mitigation actions. This third chapter enables the proposal for an integrative definition of a mitigation urban project.

The fourth chapter introduces the methodological design, offering a conceptual framework for the analysis of cases.

A process perspective is considered, from input, to process and output dimensions with specific questions to be answered in each case of study to consequently facilitate the comparison.

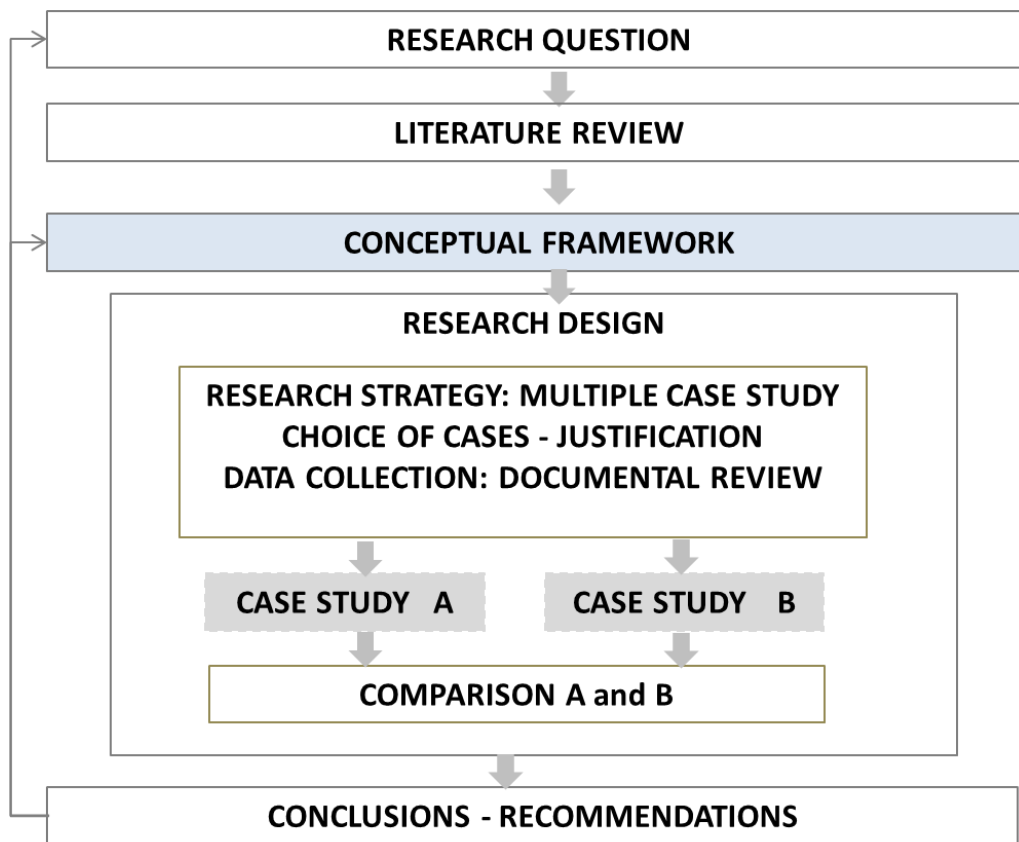
Finally, the findings are discussed and the conclusions are presented in the fifth chapter in accordance with the research question and objectives. Possible implications and future research are suggested.

Figure 1. Structure of the thesis



Source: elaborated by the author.

Figure 2: Methodological design



Source: elaborated by the author.

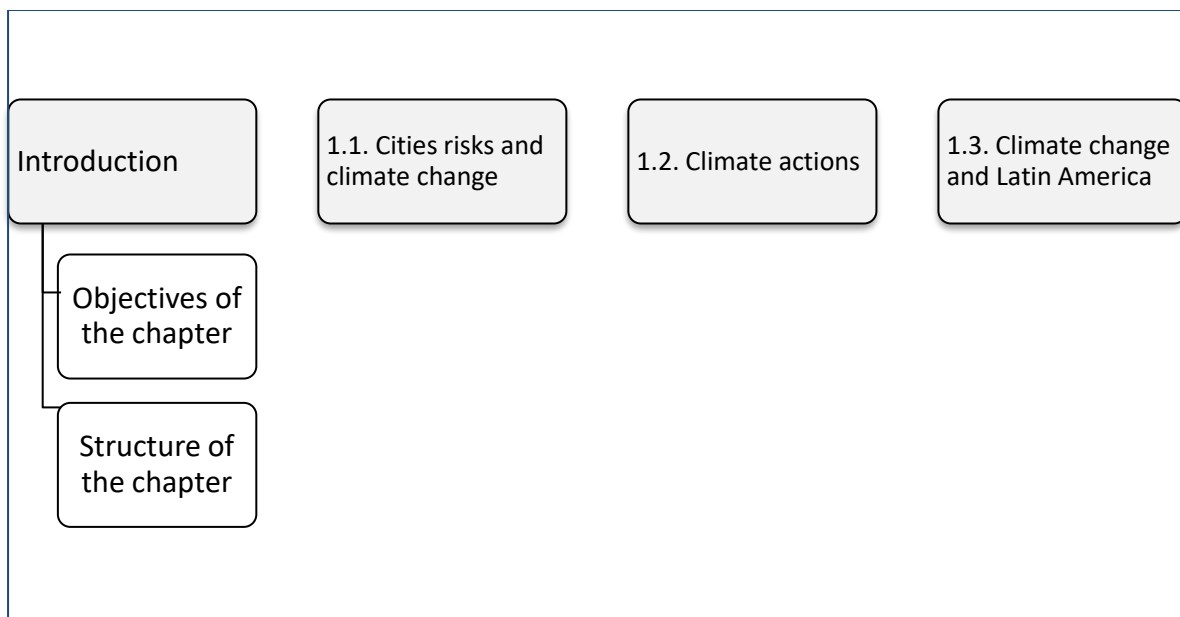
Chapter 1 Cities and climate change

Introduction

The purpose of this chapter is to apprehend how cities are responsible for climate change and at the same time to highlight a means or a tool to mitigate it. The chapter illustrates increasing issues generated by cities as the main drivers of climate change through features such as greenhouse emissions indicators and intensive energy resource-based paradigm.

The chapter presents three sections (see Figure 3), beginning with the links between growing cities and climate change. In a second section, climate actions in terms of mitigation and adaptation are highlighted. Finally, the meaningful role of Latin American cities facing climate change is introduced.

Figure 3. Structure of chapter 1



Source: elaborated by the author.

1.1. Cities' risks and climate change

Since the last decades of the 20th century the climate change concept has been capturing increasing attention among scientists of different fields, creating a science of climate change (Hulme, 2013). Furthermore, the study of climate change that could initially be related with the discipline of climatology, well developed within the science and practice of meteorology and the physics of greenhouse warming, has experienced a new condition of emergence in terms of global concerns.

According to Zillman (2009), the current interest in climate change issues has been possible due to five combining factors which occurred after the Second World War: advances in atmospheric knowledge on large-scale circulation of the atmosphere; systematic measurement of atmospheric carbon dioxide since 1957; meteorological observations using satellites; use of computer technology; and wide acceptance of international institutions to deal with global issues. The evolution of these scientific, technological and geopolitical developments triggers the transition from a descriptive climatology to a physical science (Bolin, 2007).

In terms of academic production, Hulme has identified the evolution of journals in this field in the last decade, recognizing 14 academic journals in 2010 using the term climate (Hulme, 2010), 27 in 2014 (Hulme, 2013) and since 2014, 11 new climate related journals appeared (Hulme, 2018). He noted that “these 11 additional climate journals reflect the continued salience of climate in everyday public and political life around the world, as well as the evolving scope of climate research and academic scholarship” (Hulme, 2018, p. 1).

Thus, 38 academic journals are publishing in English with the term “climate” in their titles, indexed on Web of Science and JCR Scopus. Furthermore, the academic production on climate has incorporated the term “change” more recently with the first journal called Climatic Change in 1977 and in 2009 the International Journal of Climate Change Strategies and Management was launched. Since 2010, five new journals that incorporated climate change in their title were published: WIREs Climate Change, Journal of Water and Climate Change, Climate Change Economics, International Journal of Climate Change Impacts and Responses, Journal of Earth Sciences and Climatic Change and Advances in Climate Change Research.

In 2011, the British Journal of Environment and Climate Change was published, and Climate Change Responses in 2014. Open-access journals are a more recent source of knowledge in today's scientific environment and have been contributing to the field of climate change, even if critics of predatory journals persist in terms of their integrity (Moher et al., 2017).

Climate change has emerged as one of the most important issues of the last three decades and evidence has been produced to affirm that the Earth is experiencing radical transformations due to human actions. Humans have responsibility in the transformation of the Earth since the Industrial Revolution, the evolution from the Anthropocene to the Holocene period, which should normally have spanned 11,700 years, has taken just 300 years, and this acceleration is dramatically threatening the earth's climate:

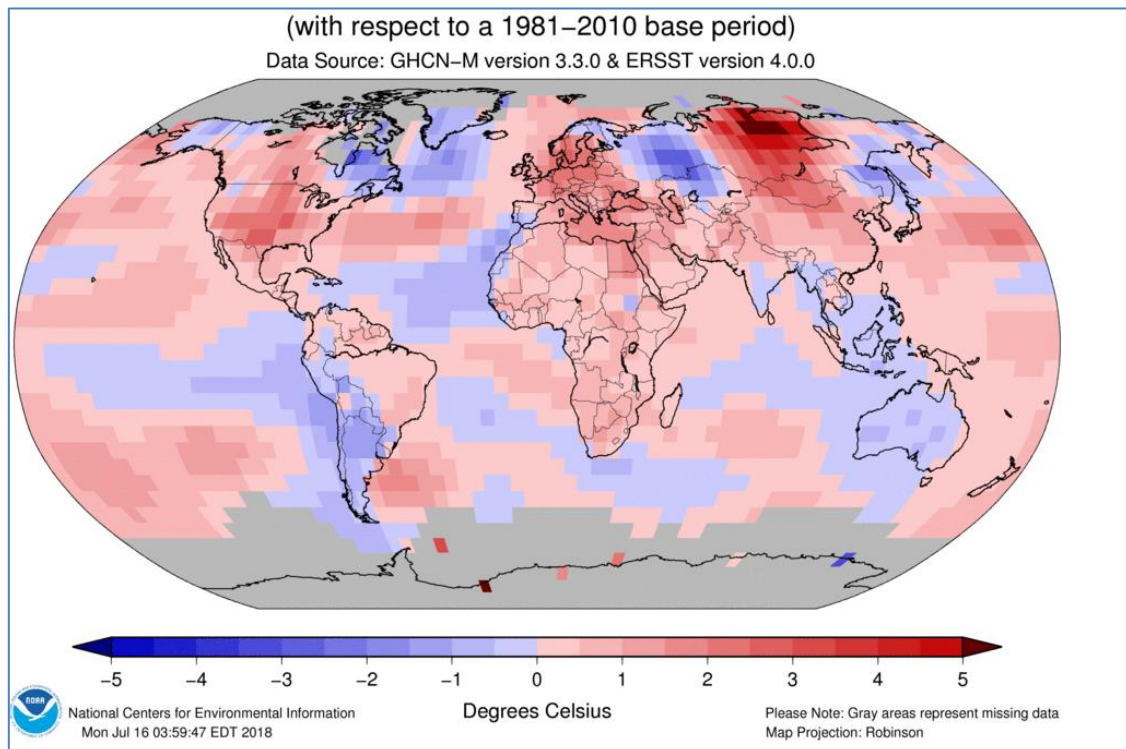
“The 11,700-year-long Holocene epoch, the only state of the planet that we know for certain can support contemporary human societies, is now being destabilized” (Steffen et al., 2015).

More tangible and diffused by mass media are changes in ice cover, sea level, ecosystems, species distributions, and extreme events (IPCC, 2014a).

According to some authors like (Reyes, 2014) and international organizations such as the Intergovernmental Panel on Climate Change (IPCC) for the year 2007-2013, and Comisión Económica Para América Latina y el Caribe (CEPAL) 2014, the increase of greenhouse emissions, (GHG) is causing significant climatic changes. It has been observed that the global average temperature, referred to the period 1880-2012, has increased by 0.85° C, that is, from 0.65 to 1.06° C.

In the same way, the average climatic projections for this century warn of an increase in the temperature by 2100 that will be in the range of 1- 3.7° C, with an increase of between 1 and 2° C for mid-century and extreme scenarios of up to 4.8° C increase by the end of the century (see figure 4).

Figure 4. Land and ocean temperature departure from average June 2018



Source: NOAA <http://www.ncdc.noaa.gov./sotc/global/201806>

In relation to the concept of climate change, “the UN Framework Convention on Climate Change (UNFCCC), makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes, and defines climate change as:

“a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”.

In opposition the IPCC, defined climate change as:

“a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer”, making no such distinction” (IPCC, 2014b, p. 141).

In 2011, the UN-Habitat report "Cities and climate change global report on human settlements", recommended the need to change the traditional way of planning cities,

which used historical climate data to project future areas of urban expansion and of infrastructures which both increase the risk areas in the face of climate change.

Similarly, the report suggested reconsidering the location of airports, ports, power plants and roads, which generally tend to be built in vulnerable and exposed areas as well as the construction of slums and informal settlements that are prone to damage due to related impacts with the weather especially in developing countries (UN-HABITAT, 2011, p. 89). In recent years, the scientific community has been investigating the relationship between cities and climate change, in particular, the urban responses that are being generated to mitigate the effects of climate change and, on the other hand, the impacts of climate change on the most vulnerable urban areas (Castán Broto & Bulkeley, 2013). International reports like IPCC 2014, have indicated that:

“In urban areas, climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, in land and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges. These risks will be amplified for those lacking essential infrastructure and services or living in exposed areas” (IPCC, 2014b, p. 141).

In its 2014 report *"Planning for Climate Change: A strategic, values-based approach for urban planners"*, UN-Habitat indicated that more than 50% of the world's population lives in cities, which are large centres of consumption and production and also large consumers of energy and logically large emitters of greenhouse gases (GHG).

In this sense, the actual building of the cities, a sector larger than transport and the industrial sector combined, consumes 40% of the energy produced and it is projected that by 2050 the demand will reach 60%. In this way, by 2030, it is expected that cities will consume almost three quarters of the world's energy production. Other authors like Magnaghi (2010), indicated that the cities of the northern hemisphere are consuming 80% of the world's energy and it is necessary to rethink the sustainability concept from a local perspective. According to the same report, there are many cities that are growing in developing countries, and are becoming large consumers of energy and emitters of greenhouse gases. This is an additional problem because it is not

known if these cities will be able to achieve future development incorporating mitigation and adaptation actions to climate change.

The emissions produced by the cities are attributed mainly to the construction of buildings, air conditioning and heating, the use of diesel vehicles and industry.

One of the most important aspects mentioned in this report was related to the role of urban planning in cities that can either increase our GHG emissions to the atmosphere or on the contrary mitigate them. This depends, for example, on the urban organization of a city, the densities, the urban mobility and urban waste management.

The management of climate change depends more and more on urban planning, and a well-planned, properly administered city is better equipped to cope with the effect of climate change.

“Urban planning is increasingly important in managing climate change because well-planned cities are better able to adapt to climate change and are more resilient to its negative impacts than unplanned or poorly managed cities” (UN-HABITAT, 2014a, p. 27). According to Paloscia et al.:

“The slums, like the South, are also a weak and all-encompassing category of the most varied denominations, in which every urban inhabited area does not conform to the logic of private property and urban planning, in the sum of boundless expanses a billion people, more than 1 in 3 of the urban inhabitants of the world. Perceived as populated and concentrated settlements outside the North, in reality they are widespread everywhere, albeit with different weights, in an intersection of spatial geographies that transcend preconstituted borders”² (Paloscia, Mataràn Ruiz, & Lòpez Castellano, 2011, p. 3)

Finally, cities concentrate the centres of economic, political and cultural activity, and at the same time they are centres of knowledge and innovation such as universities or research institutes, with a great capacity to develop and implement measures and strategies for adapting and mitigating climate change (UN-HABITAT, 2014a, p. 27).

² Author's translation

In 2017, UN Habitat once again insisted on the dangerous effects of the accelerated urbanization of cities and their relationship with climate change.

It is a fact that cities are making an important contribution to climate change, and even though they only occupy less than 2% of the earth's surface, they consume 78% of the world's energy and produce around 70% of the GHG related to energy in the world.

But at the same time, cities and towns are vulnerable to climate change. Millions of people living in cities around the world will be affected by rising sea levels, increased rainfall, inland floods, more frequent cyclones, storms and periods of extreme heat (see Photograph 1).

Photograph 1: The coastal city of San Juan in Puerto Rico was flooded after Hurricane Maria hit in September 2017.



Source: (Rivera Pichardo, 2018).

Many countries are already under threat and it is expected that the most affected populations will be those located on the banks of rivers or on slopes prone to landslides, near contaminated lands, and on water fronts in coastal areas (UN-HABITAT, 2017, p. 11).

1.2. Climate actions; mitigation and adaptation

The concepts of mitigation and adaptation were used for the first time in 1992 in the document "United Nations Framework Convention for Climate Change" (UNFCCC), adopted in the city of Rio de Janeiro during the Earth Summit. The main objective was to reduce the concentration levels of greenhouse gas emissions in the atmosphere, decreasing dangerous anthropogenic interference with the Earth's climate system, to avoid an increase in the average temperature of the planet.

In December 1997 the Kyoto Protocol was established, which came into force in February 2005 and was ratified by 192 parties (191 countries and the European Union). The Kyoto Protocol defined the legal framework and established for each of the "parties", legally binding limits for GHG emissions, in tonnes of CO₂eq (gases equivalent to carbon dioxide) for the 1990 reference base year.

The most ambitious objective proposed in the Kyoto protocol was for each country to reduce their 1990 levels of GHG emissions to the atmosphere by 5% between 2008 and 2012 (Oliveira, 2015).

Related to the planning of climate change mitigation strategies, several initiatives have been adopted such as measurement, verification, registry systems of actions (monitoring, verification and report) to reduce and limit GHG emissions, elaboration of national plans and policies, and incentives to reduce emissions.

In 2015, the European Union's energy commission (EC) increased the relevance of environmental policies for the reduction of greenhouse gas (GHG) emissions with a political incentive source, an electoral dividend for mayors who commit to reduce emissions at the local level for the mitigation of climate change (made within the Covenant of Mayors of the EU). However, actions at the national level for the mitigation of climate change generate mostly global benefits in the future as opposed to the attenuation of local pollution, which undermines the political incentive in the long term (Martelli et al., 2018).

Referring to climate change adaptation measures, emphasis was placed on the most vulnerable geographical areas, through international cooperation, increase of

resources for financing the planned cooperation, mitigation and adaptation actions, and through different financial strategies supported by public and private funds.

The validity of the Kyoto Protocol ended on December 31, 2012, and unfortunately the proposed goals were not achieved. The extension of the Protocol began, with the creation of a new international agreement which the parties decided to extend until the year 2020.

In December 2007 in Bali Indonesia, the 13th United Nations Framework Convention on Climate Change, Conference of the Parties (UNFCCC-COP) was held to establish a new international agreement, aimed at reducing GHG emissions to avoid climate change. The so-called "Bali Action Plan" was created, with new agreements and five areas of action: cooperation, mitigation, adaptation, technological development and financing (Oliveira, 2015).

With regard to cooperation actions, authors such as Paloscia et. al. (2011) point out how actions under a top-down model have a high probability of failing and suggest that the representation of non-institutional actors, especially non-governmental organizations, should be included under the modality bottom-up.

In 2009, some authors, such as Prasad et al (2009), indicated that the main objective of the mitigation action was to fight against climate change, slowing down the continuous increase of global emissions of gases to the atmosphere.

Almost ten years ago this author, underlined that in the period 1970-2004, the GHG had increased by 70% and that climate change mitigation policies related to sustainable development practice at that time were already insufficient to diminish the negative trend of the impacts of greenhouse gases and the warming of the atmosphere. This indicated that it could be more effective to introduce and implement mitigation and adaptation policies (Prasad et al., 2008).

Although the author points out that neither mitigation nor adaptation alone can protect against all the impacts of climate change, they can complement each other and jointly face the risks of climate change.

Adaptation is necessary in the short and long term to address the impacts resulting from the warming that would occur even in the lowest carbon stabilization scenarios evaluated by the IPCC, that is, 1.5 °C by 2030. The relationship between mitigation and adaptation is reflected in the following statement:

“Unmitigated climate change would, in the long term, likely exceed the capacity of natural and human systems to adapt. Early mitigation actions would reduce climate change and associated adaptation needs [...] mitigation reduces GHG emission and over time reduces the extent of increase in mean global temperature. This correspondingly reduces the cost of climate change”(Prasad et al., 2008).

The same authors Prasad et al. (2008) introduced the concept of *Disaster Risk Management*, strategies and commitments accepted internationally through the 2005 “Hyogo Framework for Action”, and explain:

“Disaster risk management recognizes that the consequences of natural hazards and climate change impacts can be reduced through mitigation and preparedness. The United Nations International Strategy for Disaster Reduction (UNISDR) refers to mitigation as “structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation, and technological hazards”.

In this regard, the author explains that there are two types of mitigation actions for disaster risk management, and divides them into "structural mitigation actions", such as improvements in the zoning ordinances of a city aimed at mitigating flood risk, landslides, earthquakes and tsunamis (see Photograph 2)

Photograph 2: Landslides control system, Miraflores neighbourhood, Lima, Peru.



Source: (Baggins, 2009).

This implies the most effective integration of disaster risk in planning, programming and sustainable development policies at all levels, with special emphasis on the prevention, mitigation, preparation and reduction of vulnerability to disasters.

The "non-structural" mitigation measures refer to the implementation of citizen security programmes and public awareness programmes, the development and strengthening of institutions, mechanisms and capacities at all levels, which can build resilience and recovery from emergencies in the reconstruction of the affected communities (Prasad et al., 2008).

It is important to highlight two aspects that arise from these definitions: on the one hand, it can be understood that mitigation actions are not only aimed at minimizing the effects of CO₂ emissions to the atmosphere, but are also aimed at mitigating natural risks in their structural definition, that is, through instruments of territorial planning and municipal ordinances. On the other hand, the concept of resilience emerges in the discourse, which in this case is closely related to non-structural mitigation actions.

Some authors pay more attention to the interrelation that exists between all these terms, to the importance of not considering them isolated, and the following is indicated:

“It is important not to limit the concept of resilience only to risk prevention and management and/or to adaptation but to also expand it to mitigation, as the urban resilience will have to face to great challenges of climate change and global environmental change, which are interrelated, we must re-think and transform our ways to produce, manage and consume the city in a more sustainable manner. This is the aim to reduce the risk and vulnerability of cities against slow and rapid on-setting of natural and human driven catastrophic events (including socioeconomic ones), mitigating their same causes, and at the same time to foster the dynamic adaptability of cities by stimulating the innovative and creative potential” (Tollin, 2015).

As early as 2011, UN-Habitat in its report *"Cities and climate change global report on human settlements"*, announced the reasons why it was important to diagnose and plan the growth of urban areas to mitigate climate change. In this sense, it was said that by that date, the rate of growth of urbanization in the world was unprecedented since the urban population had almost quintupled between the years 1950-2011.

On the other hand, accelerated urbanization processes were occurring in developing countries with a 90% urban population growth rate. The above, added to adverse meteorological events, would have a catastrophic effect in cities with little or no capacities to respond to climate change.

Another important aspect mentioned in the report was that the number of large cities and the size of the world's largest cities were increasing. It was projected for 2020, that 527 cities would reach a population of more than 1 million, while the average size of the 100 largest cities in the world would reach 8.5 million.

Most of this new urban growth was occurring in smaller urban areas, urban centres with less than 500,000 inhabitants (corresponding to roughly 50% of the total urban population), but which unfortunately often had weak governance systems and were unable to promote mitigation and adaptation actions. On the other hand, this can be

an advantage, since you can design, for example, monocentric urban centres that encourage the use of public transport with infrastructures that can mitigate the effects of climate change.

A final aspect to consider in the planning of a city oriented towards the mitigation of climate change is to incorporate geography and ecosystems such as wetlands, coastal areas, lakes and rivers (see Photograph 3). This type of geography has historically hosted urban centres where the vast majority of the world's population lives. Especially in developing countries, these urban centres are facing flooding and landslides due to the increase in rainfall and the lack of spaces or green areas that can absorb the overflow of rivers and lagoons (UN-HABITAT, 2011, p. 3).

Photograph 3: Curitiba lagoons natural mitigation of flooding



Source: (Siemens AG, 2010).

In 2014 international organizations such as the IPCC, insisted on the concept of mitigation as a human intervention that aims to reduce the sources and improve the sinks of greenhouse gases, avoiding anthropogenic³ interference with the climate

³ Anthropogenic GHGs come from many sources of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases (HFCs, PFCs and SF₆). CO₂ makes the largest contribution to global GHG emissions; fluorinated gases (F-gases) contribute only a few per cent. The largest source of CO₂ is combustion of fossil fuels in energy conversion systems like boilers in electric power plants, engines in aircraft and automobiles, and in cooking and heating within homes and businesses. While most GHGs come from fossil fuel combustion, about one third comes from other activities like agriculture (mainly CH₄ and N₂O), deforestation (mainly CO₂), fossil fuel production (mainly CH₄), industrial processes (mainly CO₂, N₂O and F-gases) and municipal waste and wastewater, mainly CH₄ (IPCC, 2014b).

system. This could allow an adaptation of ecosystems to ensure food production and seek a more sustainable economic development (IPCC, 2014b).

Other authors place emphasis on the variability of GHG emission measurements of cities, and claim that this depends on the methodologies used, in this regard:

“The exact share of urban energy and GHG emissions varies with emission accounting frameworks and definitions. Urban areas account for 67-76% of global energy use and 71-76% of global energy-related CO₂ emissions. Using Scope1 accounting, the urban share of global CO₂ emissions is about 44%. Urban areas account for between 53% and 87 % (central estimate, 76%) of CO₂ emissions from global final energy use and between 30% and 56% (central estimate, 43%) of global primary energy related CO₂ emissions” (Seto et al., 2014).

However, even if different measurement methodologies are used, the final result remains the same; cities are emitting a significant amount of GHG into the atmosphere, a process that will increase in the coming years.

Low carbon cities are a mitigation effort that can be employed in urban environments throughout the world. An integrated approach with adaptation could go a long way towards achieving responsive and resilient cities, as with urban greening efforts. Integrated approaches are preferred, as with adaptation–mitigation as well as multidisciplinary understandings, for future-proofing (Thornbush, Golubchikov, & Bouzarovski, 2013).

In 2015, UN Habitat published a report called "Guiding Principles for City Climate Action Planning", which indicated how to make mitigation and adaptation actions more effective, incorporating the concept of "action planning for climate change".

These actions are normally led by local governments and incorporate broad participation, such as private economic actors, the public sector and stakeholders. Indeed, these actions help the integration and participation of the community in the planning process and obtain the support for the initiatives and the appropriation of ideas by the inhabitants of a city.

To carry out effective planning of climate change actions, it is necessary to have empowered mayors and leadership:

“Climate action planning needs vigorous leadership to succeed. In some city governments a strong endorsement from the mayor is essential to catalysing action, while others benefit from active engagement from senior management in other words a “champion”. Support from key private sector and non-governmental stakeholders can be vital. Bottom-up leadership from proactive civil society groups can also galvanize city-scale climate action” (UN-HABITAT, 2015, p. 10).

Of course the planning processes of a city differ from each other, but the planning of climate action must incorporate at least the following aspects: it must be flexible, dynamic, interactive and inclusive. Planning should integrate the socioeconomic, spatial, disaster risk reduction and environmental planning processes at all levels, which will increase the effectiveness of urban responses to the challenge of climate change in the long term (Brunetta & Caldarice, 2017).

Therefore, initiatives and objectives of mitigation and adaptation to climate change should be integrated in the intersectorial plans and programmes, and the information of the plan’s vision should be shared among public institutions and stakeholders.

Finally, the resulting climate action plan can generate additional independent plans or integrate the climate actions in the current planning processes. For a better understanding of what mitigation and adaptation are in the context of urban planning, a comparison is offered in Table 1.

Table 1: **Integrate the climate actions (mitigation and adaptation) in the current planning processes**

Mitigation		Adaptation
<p>Develop citywide greenhouse gas inventories</p> <p>Greenhouse gas inventories determine baseline emissions, and identify key emission sources and reduction opportunities. While complying with local requirements, in order to ensure international compatibility cities are encouraged to use and international reporting methodology based on the greenhouse gas protocol standard, e.g. the global protocol for community scale greenhouse gas emissions inventories, particularly for cities that wish to comply with the compact of Mayors.</p>		<p>Conduct a climate change vulnerability assessment</p> <p>Cities conduct vulnerability assessment to identify current and future risks / impacts to people, community assets , and community functions. A comprehensive vulnerability assessment addresses physical, environmental, economic, social vulnerability , and focuses on those most vulnerable to impacts.</p>
<p>Conduct scenario analysis</p> <p>Cities conduct scenario analysis to identify possible future emission trends based on different socio-economic growth and climate mitigation assumptions or scenarios. The analysis results serve the basis for target setting and identifying actions.</p>		<p>Conduct scenario analysis</p> <p>Scenario analysis identifies risk level based on different scenarios of climate impacts, which will inform options to adapt to the potential climate impacts.</p>
<p>Asses the local capacity to reduce emissions.</p> <p>Cities assess their capacity to take action and consider how to leverage other existing policies, plans and actions such as those related to energy, environment, and urban management. This may include policies and programmes that are complimentary to mitigation efforts despite being focused on other issues.</p>		<p>Asses the local capacity to address climate impacts.</p> <p>Cities assess their local capacity to adapt to the climate change impacts. The analysis begins with an inventory of existing community policies, programmes that are complimentary to adaptation efforts despite being focused on other issues.</p>
<p>Set greenhouse gas emission reduction goals</p> <p>Based on the scenario analysis and capacity assessment results, cities sets their short, medium and long term citywide emission reduction goals , and secure political commitment to the goals. Cities are encouraged to refer to the greenhouse gas protocol mitigation goal standard when designing their goals in order to ensure international compatibility.</p>		<p>Set adaptation goals</p> <p>Based on the scenario analysis and capacity assessment results, cities set their short-medium and long term adaptation goals, and secure political commitment to them. The goals should comprehensively cover the physical environmental, economic and social impacts of climate change.</p>
<p>Identify and prioritize actions</p> <p>Effective plans identify comprehensive and integrated actions spanning multiple sectors of urban development and solve action at multiple different scales. Action are prioritized based on a transparent multi- criteria assessment in coordination with other city planning efforts and institutionalized within all municipal process and functions.</p>		
<p>Develop a plan for implementation</p> <p>Actions plans should include sufficient detail and clearly assign responsibilities so that they are actionable and can be implemented by the appropriate agencies and organizations to achieve the desired goals.</p>		

Source: elaborated by the author based on (UN-HABITAT, 2015, p. 10).

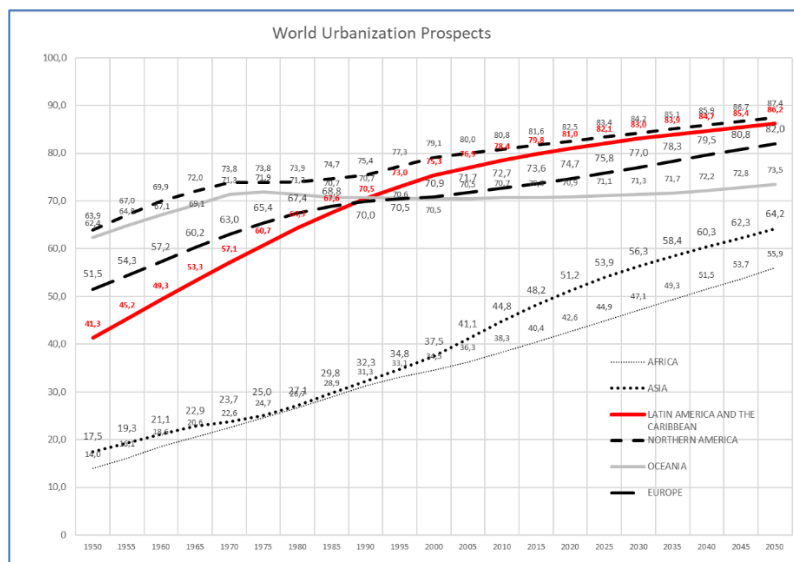
1.3. Climate change in Latin American cities

In 2013, the UN Habitat report called *"State of the world's cities 2012/2013 prosperity of cities in Latin America and the Caribbean (LAC)"* highlighted the strong predominance of interurban migration from Latin America and the Caribbean compared to other continents (Figure 5) and in this respect, the following was affirmed:

“Latin America and the Caribbean: Inter-city migration predominates: This is the most urbanized region in the world (80 per cent of the total population, compared with Europe’s 73 per cent). The urban transition in this region was achieved in the early 1960s, or about 16 years before Western Asia (the second sub-region in the developing world to become predominantly urban), and 30 and 45 years respectively before Southern and North Africa (or, on current trends, some 70 years before the whole of Africa)” (UN-HABITAT, 2013, p. 29).

Interurban migration, which represents 50% of the population growth of the cities of LAC, is mainly due to the search for new work opportunities with the aim of improving the quality of life.

Figure 5. Evolution and prospects of urban population by continents.



Source: Own elaboration based on data of UN (2014)

There are some exceptions, such as the cases of Colombia and Peru, where there was a massive migration from the country to the cities as a result of a civil war during the 1950s and 60s of the last century. According to this report it is estimated that by the year 2050, the inhabitants of the cities could reach 87%, compared to the inhabitants in the countryside. At the same time, a decrease in the urban population is projected, which is explained by the greater mobility that exists between cities.

One of the challenges facing Latin American cities is to improve their productivity and local jobs by creating roots in the population, along with improving their transportation infrastructure, quality of life, and environmental protection. On the other hand, the territorial and urban phenomena of the southern countries of the world are attracting numerous researchers through urban research laboratories (Paloscia, 2012).

In this sense, cities with a critical mass of people generating new ideas, with good infrastructure and development, both attract and retain people, private companies, investors and developers, generating more employment, innovation and knowledge possibilities and factors of prosperity. Furthermore the report also indicates the serious problems facing Latin American cities due to inequalities and poverty:

“Even though the region is more urbanized than Europe, Gross domestic product (GDP) per capita, purchasing power parity (PPP) was nearly three times lower than the European Union’s in 2010. The main reasons include chronic inequalities and mass poverty, insufficient infrastructure, poor public services, inadequate connectivity, poor governance and fragile institutions. Against this background, cities must accommodate demographic and spatial expansions, with a concomitant development of well-devised urban structures that would reduce transport and service delivery costs, optimize land use and support the deployment and/or protection of open spaces” (UN-HABITAT, 2013, p. 31).

Finally, the report reveals that in the developing countries, most of the instruments of urban planning and their respective urban regulations have been unable to prevent growth by extension of the population, allowing the change of use from rural to urban land in peripheral areas (Photograph 4).

Photograph 4: Peripheral neighbourhood, Lima Peru.



Source: author Photograph 2015.

Some Latin American cities are implementing policies of regeneration and urban renewal precisely in the poorest peripheries and those lacking infrastructure, in an effort to reverse the urban and social problems that have occurred due to migration to the main Latin American cities (UN-HABITAT, 2013).

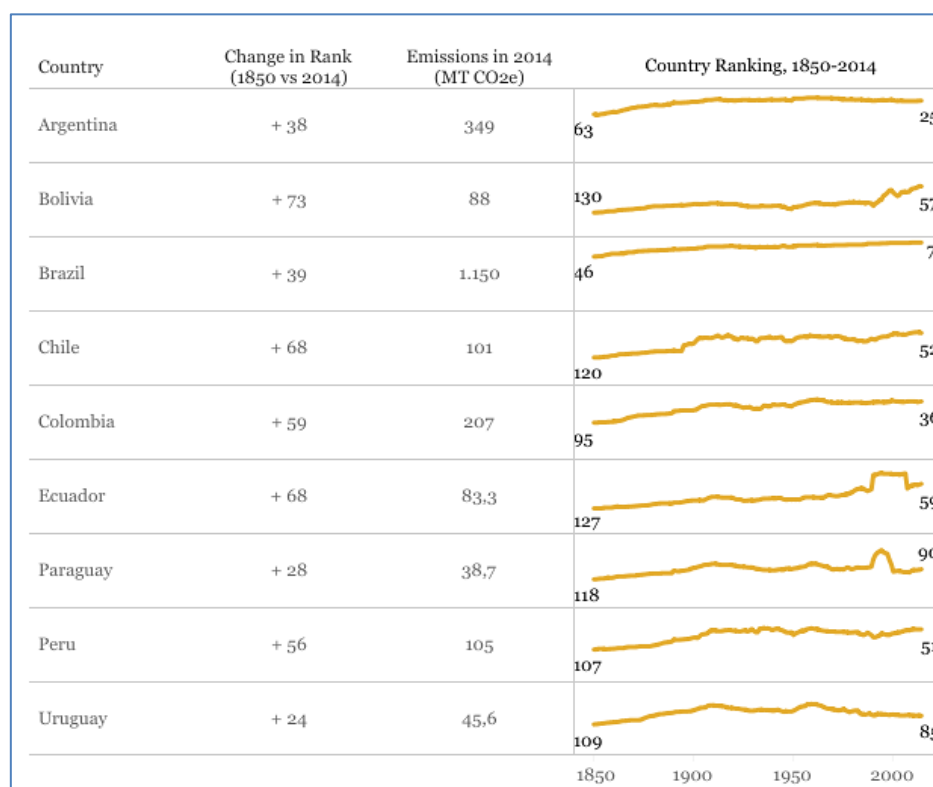
During the 21st century the countries of Latin America like the rest of the world, will have a difficult task, on the one hand to respond to the problem of climate change and on the other to maintain a rhythm of economic growth that makes it possible to improve living conditions of society while respecting the environment.

However, transforming the current style of development is not easy, because there is a close relationship between income per capita, energy consumption per capita and GHG emissions per capita in the economies of Latin America and the Caribbean, as well as in all modern economies.

In addition, any modification is highly complex especially considering some governments' incentives to subsidize fossil fuel consumption.

Currently the Latin America and Caribe region emits between 9 and 10% of the world's total GHG emissions, therefore it is not a historically important emitter but at the same time this is a territory vulnerable to the impacts of climate change (Figure 6).

Figure 6. Ranking and GHG emissions 1850-2014 of South America countries



Source: World resources institute, 2019.

Global GHG emissions from cities are between 50 and 70% and 15% of the world's urban population lives in Latin America and the Caribbean. Therefore, LAC cities need to reduce their emissions by 10-20% to close the "emissions gap" which means they could provide 1- 2% of the global solution (Rodriguez, 2015).

To achieve an effective change, a great transformation of the current model of growth and the application of public policies are necessary to move towards a more sustainable development (Sánchez & Reyes, 2015).

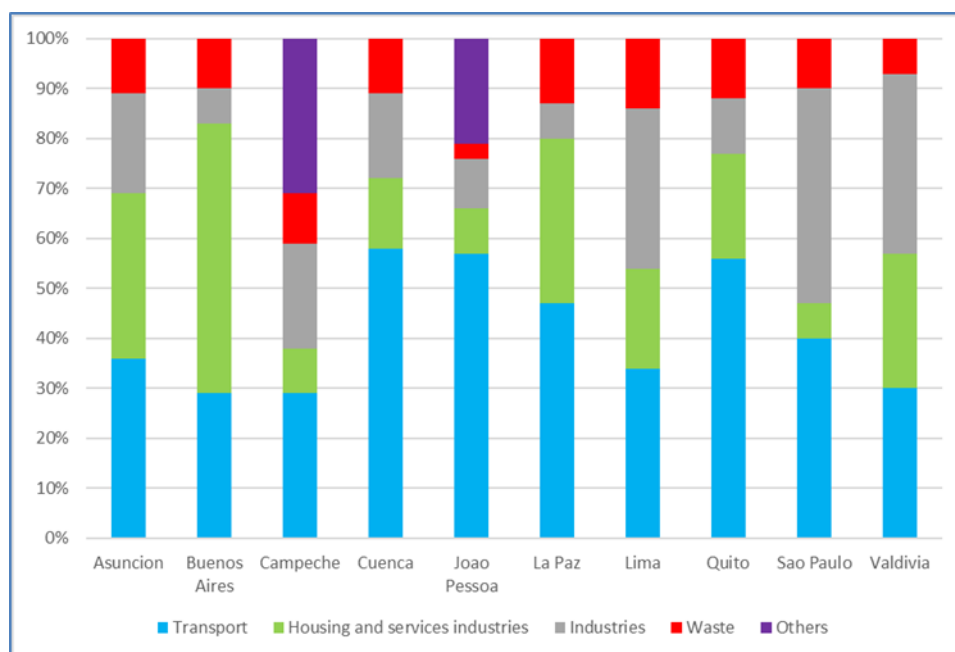
Today, various efforts are being made in the Latin American context to implement public policies that incorporate mitigation and adaptation actions to climate change to stabilize the increase in global temperature at no more than 2° C by the middle of this century (Sánchez & Reyes, 2015).

In the case of precipitation patterns, there is great uncertainty in its projection and a noticeable regional heterogeneity, so in some areas an increase in rainfall is expected and in others a reduction. It is thought that the frequency and intensity of extreme precipitations will occur more in mid-latitudes and in humid tropical zones.

In the Latin American continent, changes in rainfall patterns are already being noticed, and forecasts for the end of the 21st century project a reduction in rainfall of 22% in north-eastern Brazil, which could have devastating effect on the rainforest basin. In the case of south-eastern South America, however, the precipitations will increase by approximately 25%. In this sense, the phenomenon of the Niño cycle will continue to be an important factor in the intensification of rainfall in the tropical Pacific, due to an increase in humidity caused by rising temperatures (Sánchez & Reyes, 2015).

Most efforts to reduce GHG emissions in the Latin American context are concentrated in the transportation and energy industries (Rodriguez, 2015), see Figure 7. In the Brazilian and Colombian cities, innovative transport policies and programmes have been reported as effective policies to mitigate anthropogenic carbon dioxide CO₂ emissions on a local scale (Reynolds et al., 2017).

Figure 7. Industries' participation in GHG emissions in Latin American cities



Source: Based on Rodriguez (2015).

An example can be found in Medellín, Colombia, where the cable cars were being used to provide access to the city's peripheral neighbourhoods with serious social problems, promoting social inclusion (Photograph 5). This means of mass public transport also offers complementary benefits, such as the compensation of carbon emissions when operating with energy produced by a hydroelectric power station. The

above is interesting because urban areas represent between 71 and 76% of CO₂ emissions related to energy.

The author calls attention to the danger of deforestation in the peri-urban areas of sub-tropical cities in Latin America and the important role of tree planting in cities for the regulation of CO₂ on a local level. However, more studies are needed to evaluate the real effectiveness of these programmes (Reynolds et al., 2017).

Another example was the municipality of Quito that in 2010, created a *Climate Change Panel for Quito* to serve as a knowledge support structure and hub for the Climate Action Plan:

“Quito has directed much attention and funding to socially vulnerable groups, especially to residents on the hillsides and slopes and indigenous farmers in the peri-urban areas of the city. The municipality has put in place an early warning system, constructed new water and sewerage infrastructure, implemented a relocation programme of 600 families to new social housing, and expanded slope protection programmes to include 300,000 hectares of newly reforested land” [...] “Between 2013 and 2014, local government released additional funds to build capacity against climate risk in different community based organic farming and agro-ecology projects” (Chu, Anguelovski, & Carmin, 2016).

There are initiatives such as "Emerging and Sustainable Cities", or the "Footprint of Cities" projects that brings together more than 50 medium-sized cities in LAC with a total population of more than 50 million inhabitants (about 10% of the population of urban LAC), and these show a panoramic view of the situation of CO₂ emissions. In this regard, sectors with a greater contribution to emissions have been identified; transport accounts for about half of emissions (42%), while the housing sector and the service industry account for 23%; Together, they accumulate two thirds of the total emissions in the cities of Latin America and the Caribbean (Rodriguez, 2015).

Photograph 5: Peripheral areas vulnerable to landslides, Medellín, Colombia



Source: (Siemens AG, 2010) Índice de Ciudades Verdes de América Latina, 2010.

An *Organisation for Economic Co-operation and Development* (OECD) report from 2014 indicates that investments in urban infrastructure with low carbon emissions and climate resistance are associated with low incremental costs and produce local benefits, for example, sustainable urban transport can reduce bottlenecks, air pollution and greenhouse problems. However, public investments are insufficient to meet all needs and cities should be able to attract private capital to develop green urban infrastructure projects (OECD, 2014).

The United Nations report of 2015, indicated that Latin American cities have developed actions that can be mitigation and/or adaptation to climate change and there are several examples of initiatives, policies and actions aimed at mitigating emissions of greenhouse gases (GHG) and adapting to climate change. However, most cases have focused on mitigation actions and there are only a few cities in Latin America that are being studied in their planning processes and mitigation, adaptation and governance alternatives; for example, Quito in Ecuador and Río de Janeiro in Brazil (United Nations, 2015). Other cities like Bogotá, Mexico City and Santiago (Figure 6) have also been investing in mitigation actions with a high level cost to face temperatures, flooding and mass movements (ARUP & C40, 2015).

Some authors highlight that a lot of Latin American countries have adopted the "Clean Development Mechanism" (CMD), as mitigation actions against GHG emission to leverage mainly projects of greater energy efficiency and changes in the energy matrix

which affect the decrease in GHG. Mechanisms such as the reduction of emissions due to deforestation and forest degradation (REDD) have also been applied and "green funds and trusts have been established to finance the different mitigation measures through the acquisition of new technologies applicable to the more polluting productive sectors" (Sánchez & Reyes, 2015).

Photograph 6: Vulnerable to floods and excessive rainfall, Santiago, Chile



Source: (Siemens AG, 2010).

Additionally, adaptation and mitigation efforts are important to achieve the sustainable development of cities, and at the same time, to assure additional benefits such as; a better quality of life, ensuring a supply of food and energy, efficient use of natural resources and greater technological development.

All these additional benefits have positive significances for the inhabitants of a city, especially in the most vulnerable neighbourhoods and must be complemented with national resources and programmes, with policies and decisive actions to face the challenge of climate change in Latin America. At the same time the author pays attention to the limitation of adaptation actions, and points out in this regard:

“The impact of adaptation measures is ultimately limited, however. Even if they are undertaken, some irreversible damages would remain as these measures can only ameliorate the socioeconomic impacts of climate change. Adaptation measures do not generally result in the restoration of lost natural and cultural capital, which will likely affect future generations (Vergara et al., 2013).

Conclusions

There is a general consensus in the field of science, and in international organizations that the mitigation of climate change is the great challenge of this century.

Studies show that the increase of temperatures by human action, will have a strong impact on many areas that are vulnerable and exposed to climate variations, especially in coastal and subtropical areas.

In the beginning, the most developed countries were considered the main culprits responsible for CO₂ emissions to the atmosphere; subsequently, and mainly due to the increase in the number of people living in cities today, developing countries, especially in Latin America, were included in this group. These countries will experience a considerable increase in the population of city dwellers for the next 100 years.

Until 2007, it had not been thought that cities could be part of the climate change problem, and only industries such as thermoelectric plants, waste treatment plants, infrastructure and agriculture were blamed.

Cities concentrate more than half of the world's population and for the next few years it is estimated that this figure will increase. Many of these cities are located in coastal areas or neighbouring rivers or lagoons exposed to changes in climate and some are already suffering the consequences of these changes.

However, studies have also indicated the direct relationship between cities and climate change, mainly due to CO₂ emissions into the atmosphere. Many studies blame the cities for the increase of GHG emissions but at the same time indicate that these are part of the solution to the problem.

Within this context, Latin American cities will increase their population in this century and many of them will be very vulnerable to climate changes, especially cities located in subtropical areas.

The first time the terms mitigation and adaptation were used was in 1992, and they were introduced in the agreements of the Kyoto protocol five years later. In this sense, both mitigation and adaptation actions are important to combat climate change.

This thesis is supported by several authors and institutions that are developing methodologies to be implemented at the level of local governments and their inhabitants.

To combat climate change, programmes are being implemented in many cities to plan mitigation and adaptation actions and in association with this last concept the term resilience has been introduced, indicating that many studies see the effects of climate change as irreversible and the way forward is to prepare for future disasters:

“The goal of becoming a “resilient city” has been crucial for climate proofing cities, yet arose before the concept of resilience was translated from diverse disciplines into a coherent framework for urban systems in the scientific context. The concept of resilience has undergone a gradual sprawl and a simplification in both its meaning and its application. This has happened because of the lack of research and a poor understanding of how to operationalize the metaphor of resilience in the particular context of cities. Both factors, we argue, have weakened the potential of the concept of urban resilience” (Chelleri, Waters, Olazabal, & Minucci, 2015, p. 181).

Sennett (2018) insists on the need to move towards resilience and adaptation and abandon the idea of sustainability, because according to him this concept indicates no change in time, adapting to the changes that are coming is precisely what we must do from now on. Other authors maintain that we must not abandon mitigation actions because if they are not being implemented, the adaptation actions will be less and less efficient; therefore the idea is to incorporate both concepts in future actions or projects. In any case, we can conclude that on this issue the discussion is open and that many cities worldwide are projecting mitigation and climate adaptation actions assuming that if the global temperature cannot be reduced by 1.5 degrees by 2030, according to the latest report of the IPCC (2018) the effects of climate change will be irreversible.

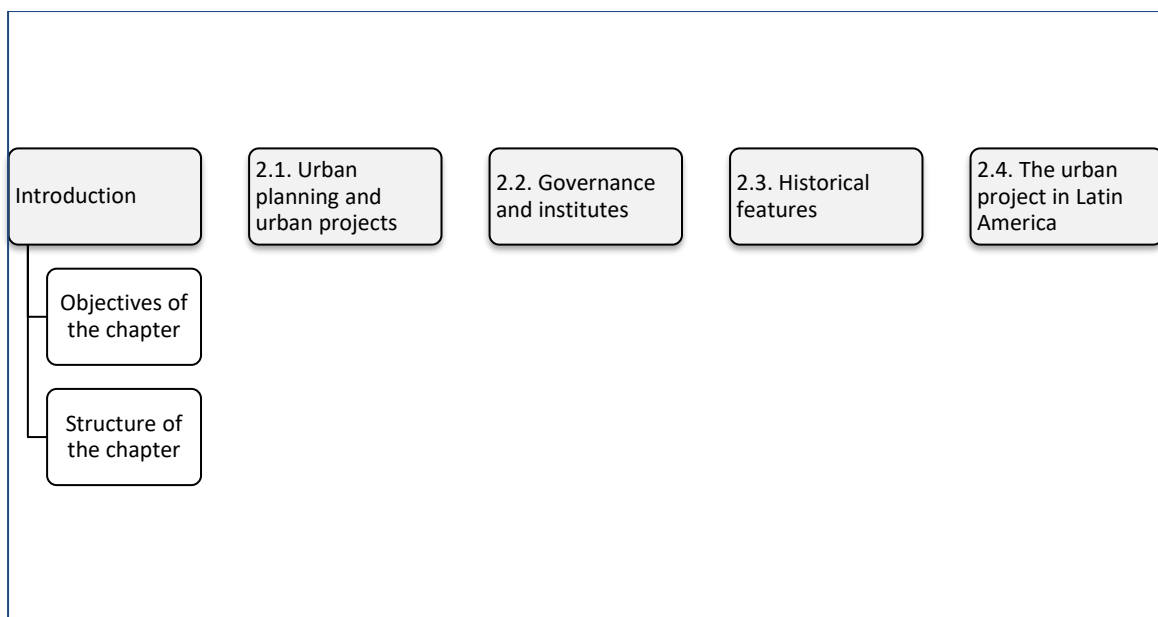
Chapter 2: Urban planning and urban projects for climate change mitigation

Introduction

The aim of this chapter is to present how urban planning through urban projects is linked with climate change and what its impact is on a city scale.

The chapter is structured in four sections as shown in Figure 8. The first section presents urban planning and modern urbanism, especially in Latin American cities. The second section highlights the importance of governance and urban institutes in this scenario. The third part is dedicated to the historical features of urban projects in the context of Europe. Finally the chapter embraces the urban project concept in Latin America.

Figure 8 Structure of the chapter 2



Source: elaborated by the author.

2.1 Urban planning and modern urbanism in Latin America

Some of the definitions of urban planning can be found in the following quote:

“Urban planning refers to the spatial distribution of residential, commercial, industrial, and recreational activities over a widespread area and generally involves integration of various components of planning, namely, land-use planning, transportation planning, and environmental planning” (Levy, 2010).

Twelve years ago some authors, highlighted the important role of urban planning, which allowed regional and local governments to have the capacity to respond to changing social, economic and environmental conditions by controlling the distribution of various land uses and planning decisions related to local development (Berke & Godschalk, 2006).

In 2014, a report by the Organization for Economic Co-operation and Development (OECD) called *Cities and Climate Change National governments enabling local action*, affirmed that cities, by applying effective urban policies through urban planning instruments, can influence good design of infrastructures so they can withstand the expected increase in climate change.

At the same time, efficient planning can improve the performance of the energy consumed and the CO₂ emissions of the built environment. For example, instruments or tools for urban planning, especially those for land use, are particularly important to reduce vulnerability to floods and other climate risks events through urban regulations.

The latter is generally known to local governments, technicians and professionals working in municipalities, but regional and national governments must provide policy guidelines, develop technical capacity and facilitate the exchange of information between jurisdictions when dealing with better management of climate-related risks. Another important concept that emerges from this report is integrated urban planning, which is fundamental for the change of land use, infrastructure, zoning proposals that can increase or reduce the exposure and vulnerability of urban dwellers especially in the poorest neighbourhoods which in most countries are often concentrated in parts of the cities that are most exposed to climate risks.

Finally, strategic urban planning and transport policies are interrelated with those of zoning, natural resource management and the use of renewable energy, which has an impact on the amount and type of energy required to travel within a metropolitan region (OECD, 2014, p. 16).

Recently some researchers have observed that the role of urban planning policies is fundamental for the promotion of sustainability, environmental management, intergovernmental collaboration, mitigation of natural hazards and urban resilience. On the other hand, urban planning policies are capable of influencing growth and development patterns, considering public health aspects that can incorporate mitigation and adapt significantly to climate change (Raparathi, 2018).

Other authors maintain that "integrated planning" (IP) is one of the most important instruments that can be used to model the city and the spatial distribution of urban activities and to obtain spaces to inhabit without destroying nature (biophilic). This means abandoning the static plans used in the 20th century, which were characterized by the use of large areas of land with investments in infrastructure and land use planning in favour of more innovative urban solutions, greater resource efficiency, and active participation of the communities as social agents.

The adoption of new tools such as granular planning and flexible planning can create spaces for learning through urban experimentation and allows a city to vary the types of land use, densities and built shapes (height for example) in a neighbourhood for financial, environmental and social reasons. Integrated planning (IP) is fundamental to achieve two objectives, compact urban growth and habitable, functional and socially mixed neighbourhoods. The dimensions of IP according to Salat (Swilling & Hajer, 2017) are eight: compact, articulated and polycentric intensification; nodal agglomeration; flexibility and alignment with market demand; connectivity through scales and vibrant public realm; small perimeter blocks with active edges; mixed use; fine grain diversified plot patterns; the construction of green spaces, natural systems and bioclimatic urban fabric (Swilling & Hajer, 2017).

a) Historical features of urban planning in Latin America

In 1933 and after the 4th International Congress of Modern Architecture (CIAM) that resulted in the drafting of "the Athens charter", the developing countries were initiated

in the paths of the modernist ideas of architecture, design and planning coming from Europe and the United States. Urban design brought about the spatial restructuring of cities, through new rational principles:

"The urban modernity and the rationalist urbanism promoted by the Modern Movement focused on the principles of a complete renewal of urban life in the function of the fundamental elements of industrial modernity. The paradigms of the modern city, introduced the ideas of hygiene, the garden city and, above all, the functional city, promoted by the CIAM of 1933 in Athens, framed within the projects of solution to the urban consequences caused by industrial phenomena: pollution, insalubrity, spatial disorder, overpopulation, urban overcrowding, industrial agglomeration (...)" (Castrillón Aldana & Cardona Osorio, 2014).

The creation of new urban areas, new settlements or the remodelling of abandoned urban areas would be carried out through a preconceived "holistic plan, governed by precise aesthetic and theoretical principles that responded to existing material needs" (Burgess, Carmona, & Kolstee, 1997).

The new rationalist ideas opposed the model of a compact, monocentric and monotonous grid city inherited from the Spanish colonization. Conversely modern ideals bet on a new urban structure incorporating the characteristics of the site, the topography and the landscape, through four functional criteria:

"The internationalization of the urban principles of the Modern Movement was in the hands of the extraordinary dissemination of the Athens Charter in 1943, eight years after its formulations at the CIAM in 1933. The fundamental problems of urbanism and modern architecture announced in this publication would be characterized by the idea of the functional city, in which its principles would be classified in what was believed to be the four basic functions of the city: dwelling, working, recreation and transportation"⁴ (Castrillón Aldana & Cardona Osorio, 2014).

⁴ Author's translation

Functional urbanism was expected to solve the problems of urban renewal in developing countries, adjusting densities, incorporating services, solving traffic congestion and avoiding the speculative character of the subdivision of land. The modernist principles considered circulation as an important element to establish the rationality of urban designs.

To order the modernist city and define its urban form, the plans had to consider the correct distribution and location of the work zones, the residential areas, and the industrial zones, which had to be separated from the houses by green areas. At the same time, business centres and commercial activities had to be located at important intersections of circulation, enhancing polynuclear forms. The designs and plans should also include reducing travel times between workplaces and places of residence (Burgess et al., 1997).

During the last century in the Latin American context, urban planning policies played an important role in the growth, development and promotion of cities. At the end of the 20th century, urban planning instruments and policies began to promote the sustainability of urban centres by incorporating aspects such as environmental protection and the reduction of natural risks (Berke & Conroy, 2000).

In this context, not all Latin American cities had been planned and managed in the same way. Each city has its own administrative culture, which is the result of different historical processes, in which the social, geographical, political, economic conditions, the urbanization process and the demands coming from civil society play a part (ONU-HABITAT, 2012).

At the end of the 70s, the urban planning model consisted of physical planning, based on the idea of rather rigid "territorial ordering", implemented by three basic instruments: the zoning of land use, the control of densities and the extension of basic service networks.

In the 90s this model suffered a crisis due to the accumulated deficit of services and urban infrastructures. Its abandonment was also caused by policy guidelines that advocated the reduction of public intervention in all areas, including the territory and the urban land market (ONU-HABITAT, 2012).

Brazil and Colombia appear as the countries that lead a second commitment to physical planning from a more local perspective. These countries have the most developed legal frameworks and in Colombia, are promoted by initiatives from the central government itself whereas in Brazil, they are much more associated with the pressures of social movements. With multiple implementation experiences, some more successful than others, the social, technocratic and political movements have reformed the local discussion about the government of the territory and demanded the attention of the state with proactive policies for precarious settlements (ONU-HABITAT, 2012).

Some cities, such as Bogotá, Medellín and Bucaramanga in Colombia, and Curitiba, Porto Alegre and Diadema in Brazil, stand out for territorial planning exercises with a strong focus on improving the living conditions of their precarious settlements (ONU-HABITAT, 2012).

At the end of the 80s and the beginning of the 90s, important conceptual changes began in the practice of urban planning, related to the processes of globalization of the free market, trade, investment and financial flows, and development strategy oriented to the sector of goods and services. The main conceptual change in urban planning in the neoliberal period was the consolidation of so-called 'strategic planning' as the dominant planning style, introducing concepts that were taken from "the theory of games and business administration, whose objective was to make plans for the success of actions that were based on the rationality and interdependence of competing participants or competitors" (Burgess et al., 1997).

The urban strategic plan incorporated the concept of "vision" of the city, enhancing the competitive advantages, its strengths and opportunities, elaborating structure plans and business plans for a city inserted in a globalizing economy.

Strategic planning was based on a set of strategies that guided a participatory, flexible and integrated system and emerged as a proposal for traditional planning that was rigid from the top down and without consensus from the social actors involved. Strategic planning incorporated four main actors:

"Local government, entrepreneurs, knowledge and industry (universities and specialized centres) and the community, through the definition of objectives, and common benefits, these actors evaluated and prioritized plans, programmes and projects that support social equity, efficiency economic and environmental sustainability" (Burgess et al., 1997).

In the 1990s, there was an improvement in the governance of the mayors who had a vision of the city and more flexible urban strategies that could change rapidly in the face of the scenarios of a globalized economy. Nevertheless there was still to be developed greater participation of the community in decision-making, improving electoral representation, combating the increase of urban poverty, urban violence, quality of life and environmental degradation were still to be developed (Burgess et al., 1997). During this period and in parallel, there was an increasing concern in the planning of cities for the urban environment, mainly due to the Rio Conference in 1992, with the incorporation of a new concept, "challenge of sustainability".

Global and local environmental problems began to be seriously considered in the mid-1990s, where environmental concerns had to go further than simply adopting mitigation measures through environmental impact assessment, governments began to try to implement "Agenda 21" and "Local Agenda 21" guidelines on sustainable urban development and the environmental dimension was introduced into urban planning and management models, especially urban renewal plans.

At the beginning of 2000, many important Latin American cities opted for "strategic planning" as a new instrument able to implement, in a short period of time, a vision of the city through objectives, plans and programmes.

Regrettably, few municipalities had the necessary regulatory instruments, technical capacity and management tools to carry out these transformations. When making a comparative study of several Latin American cities, such as Santiago in Chile, Lima, Peru, and Rosario and Buenos Aires, Argentina, which have implemented strategic planning, some authors indicate that success depends on the political will of mayors and local authorities and requires a concerted dialogue with key stakeholders, who have a fundamental role in the process of implementing urban policies.

It also requires the thematic approaches of the participatory system and the technical capacity of those involved (Steinberg, 2005).

In the year 2006 in Vancouver Canada, the World Planners Congress gave rise to a manifesto on planning and was known as the "Vancouver Declaration". In that document, 10 principles were proposed to give a new approach to urban planning directed towards sustainability, people, economic opportunities and the environment, creating the foundations for future "climate planning".

One of the aspects that the new urban planning should incorporate is the integrating principle, that is, combining and coordinating economic planning and physical planning with environmental planning towards greater efficiency, with public and private budgets and the involvement of stakeholders and society. In order to achieve this, strategic planning was selected due to its flexibility and citizen participation involving all sectors of the community.

From the point of view of governance, another of the characteristics that these plans should have was the necessary decentralization of local governments, which play a fundamental role in being protagonists and achieving the empowerment of community organizations at neighbourhood level. The foregoing does not deny the importance of urban governmental policies that must ensure a good management of human settlements at a more general level of planning (ONU-HABITAT, 2012, p. 18).

Years later, authors recommended the need to incorporate mitigation and adaptation to climate, in the "spatial planning" of cities, as an important consideration:

“Both mitigation and adaptation have a spatial dimension. It is becoming more and more a pragmatic challenge for spatial planners to include climate change as an important consideration in the planning process, especially in the context of sustainable development. Although spatial planning is sometimes referred to by climate scientists as the ‘switchboard’ for implementing mitigative and adaptive measures at the local and regional scale, it has until now fulfilled only a limited role in the climate change debate” (Biesbroek, Swart, & Knaap, 2009).

The "spatial planning" concept is not clear, due to the idiosyncrasies of each country. However, spatial planning has a holistic approach and recognizes the interrelationships and effects of spatial measures in a long-term perspective. In this sense it is affirmed that:

“Spatial planning coordinates the different relevant socio-economic objectives and desires, for example, the development of transportation systems, local economy and housing, and objectives with a strong environmental component, such as nature development, water management and agriculture” (Biesbroek et al., 2009).

Due to the growing attention of the scientific, political and social world to climate change, during this period the spatial planners were challenged to include climate change considerations in the city planning process (Biesbroek et al., 2009).

2.2 Governance and urban institute for climate change actions

Some of the definitions of governance can be found in the 2014 UN-Habitat report, *Planning for Climate Change: A strategic, values-based approach for urban planners*, which says:

“Governance is a widely used term that can be defined as how important decisions are made and carried out by the institutional bodies that make them. These decisions are typically made by different levels of government (national, state/provincial, local) the agencies and organizations associated with them, and may often involve some of the stakeholder groups (UN-HABITAT, 2014b, p. 79).

The same report indicates that decision making in a hierarchical top-down governance model often fails to involve the groups most vulnerable to climate change. A large number of studies suggest that the participation of poor and marginalized groups in decision making is an important part of improving the conditions of informal settlements or places more exposed to climatic events.

Moreover, Steinberg (2005) mentioned that there were several examples of cities in Latin America that were using two models of citizen participation, where traditional planning coexists with the

ideas of coordination of the inhabitants. One is the 'top-down' approach, which points to a strategic demand of the city as a total entity and the other is the "bottom-up" approach, which represents the articulation of citizens' social demands. However, planning through these two dimensions was not easy to implement.

In places where participatory prioritization methods have been used, it was not an immediate success, because the technical staff at the top did not accept all the results of the participatory process. On the other hand, citizen participation tends to increase expectations and stimulate initiatives that, in the end, are not feasible and generally do not have funding.

For this reason, in theory, there is a need to establish realistic financial limits for participatory processes and "micro planning" at the beginning of said processes.

This explains why a growing number of cities have started to experiment with the concept of "participatory budgeting, with a focus on what is feasible and realistic" (Steinberg, 2005).

The UN-Habitat report highlights that cities with decentralized authority on a local level combined with good working relationships with national and state and / or provincial governments, can implement policies and programmes more effectively and efficiently than cities where decision making is centralized at the highest levels of government. In this same sense, climate change is a dynamic process in which unforeseen problems can arise, and the occurrence of climate-related disasters can present itself more frequently and more intensely.

Consequently, a city requires flexible agencies and adequate management systems to respond to and anticipate these surprises. The evidence suggests that an inter-institutional and inter-governmental body dedicated to addressing the potential and real impacts of climate change (such as a central planning team) is desirable (UN-HABITAT, 2014b, p. 79).

One of the alternatives that are known worldwide, and that are being applied some cities with good results, are the so-called urban institutes, planning and management tools oriented towards a sustainable urban development of the cities.

Indeed there are several types of tools, for example, urban institutes which can be organized and managed under a variety of provisions, with property and funding sources being the most important; The governments; either central, regional, state, provincial or local and working alone or in association, and private entities which, can create and own urban institutes.

The ownership and financing of urban institutes, taking as an example international cases, can be grouped into four main categories: those pertaining to and directed by the municipalities; those owned and directed by associations of local governments; those belonging to and directed by higher levels of government; academic institutions associated with different levels of government (OECD, 2014).

According to a 2013 OECD report, the institutes that belong to and are managed by the municipalities have full control and also cover all operating and development costs. The territorial sphere of interest of the institute is the same as the municipality. Examples of such urban institutes include the Institute of Planning and Environmental Management of Alcalá de Henares in Spain, the Institute for Municipal Research of Tokyo in Japan, the Institute of Urban Development of Amman in Jordan and the Institute of Urban Planning Research in Curitiba, Brazil. The latter has been enjoying legitimacy, credibility and prestige for more than 50 years (OECD, 2014).

The Institute of Urban Development and Planning in Curitiba *Instituto de Pesquisa e Planejamento Urbano de Curitiba* (IPPUC) is an outstanding example of an institute established and supported by the municipality. The model is widely spread throughout the world, and in Latin America there are institutes of this type in Argentina, Brazil, Colombia, Ecuador, Guatemala, Mexico, and Peru. The city of Curitiba is internationally recognized as an example of good practice in urban development planning, and most studies individualize the work of IPPUC as having a central role in this success:

“The Institute supported the urban plans and innovations that guided the expansion of an urban area whose growth accelerated in the 1960s, transforming a city of 200,000 inhabitants into the core of a highly populated metropolitan region with more than 3 million inhabitants, comprising 26 municipalities, four decades later. Among the strengths of the institution are a clear territorial approach, strong links with the structure of local government and close collaboration with the community and local civil society organizations” (OECD, 2014).

The IPPUC is continuing to be a central actor in the development of Curitiba today, and is a reference for planning institutions worldwide. Its sustainability is mainly the result of the impact that its proposals have had on the quality of life of the city. Since the late 60s, urban planning has been on the agenda of all mayors and the IPPUC has played a fundamental role for the municipality as a generator of their urban plans and projects (OECD, 2014).

According to some authors, for instance Swilling et al. (2017), six types of urban government can be identified, and there may also be mixed typologies. The models are: the cronyism-based modes formed around powerful political personalities; the corporate modes formed around formal official coalitions of powerful local political elites which work closely with business and/or community interests; managerial modes that are based on formal bureaucratic systems and rules controlled by powerful officials who make decisions to achieve public objectives; pluralist modes emerge in cities where there are political rivalries and diverse interests where competing blocks seek to direct the political agenda towards their own material interests; popular democratic modes which tend to form around politicians who form alliances with popular grassroots movements, and where democratic participation, inclusion and accountability are the key symbolic practices that legitimize a populist governing coalition; and finally entrepreneurial urban governance (Swilling & Hajer, 2017).

In relation to the entrepreneurial urban governance typology, this is characterized by politicians and urban policy officials working closely with entrepreneurs oriented to innovation and knowledge networks.

The most typical characteristic of entrepreneurial urban governance is when those responsible for the city's urban policy form coalitions and/or open associations with a range of institutions, for example, institutes or universities, public agencies, social enterprises, civil society formations, creative industries and small local businesses, to address a particular challenge that tends to create the basis for a more durable alliance to address broader challenges.

According to the authors, this new form of urban government has three main components which are: business governance modes, urban experimentation and systemic inclination through networks. Understanding the city as a laboratory in which you can experiment with solutions for the future, has become the hallmark of the global green transformation in the age of information. However, as the authors argue, this model of governance can take several paths. One can be urbanism closely linked to the smart city led by companies to boost the economy, productivity and competitiveness of cities.

Another possible path would be towards a more heterogeneous and inclusive, informed, creative and open model, with a city that bets on urban experiments aimed at finding ways to rebalance computer development and human well-being. and the sustainable use of resources (Swilling & Hajer, 2017).

Some examples of good governance can be found in Latin American cities like Bogotá which has been praised for its bus rapid transit system, known as the *TransMilenio*, its cycle paths (closing the streets to traffic on Sundays to encourage bicycling), and the use of civic education as a means of reducing violence in the streets this is a unique reform promoting the citizens' culture introduced by mayor Antanas Mockus.

More recently Medellín, once branded as the cocaine and crime capital of Latin America, has been touted as a model for best practices in good governance and social urbanism.

Another example is Porto Alegre in Brazil which has launched participatory budgeting, a model that has been replicated by well over 1,000 municipal governments in Latin America and around the world, and is promoted as an example of a new “participatory planning” that breaks with the traditional model of decision making driven by technocrats and elites (Angotti & Irazábal, 2017).

The cities are responsible for between 30% to 70% of global greenhouse gas emissions to the atmosphere, and consume roughly 60% of the world's energy (Van der Hoeven, 2012) which is demonstrated through several scientific studies carried out in the last 25 years. Therefore cities are part of the problem but at the same time they are also part of the solution, which was already established in 2011 in the report of UN-habitat:

“Cities can therefore be seen as part of the problem of climate change and reducing GHG emissions in cities is a key policy challenge. However, cities can also be seen as part of the solution to addressing climate change [...] both in terms of the role of urban governments and because of the potential for private-sector and civil society actors to respond to climate change at the urban level”

In the same report of 2011, UN–Habitat informed about the importance of incorporating civil society represented in all its forms in order to mitigate the effects of climate change in cities. This means including community-based organizations, especially underrepresented minorities, NGOs, religious organizations, and women's organizations (UN-HABITAT, 2011, p. 87).

Another important aspect highlighted in this report was the importance of the municipal authorities (mayors, councillors and directors) as key figures to face the challenge of mitigating climate change. In this sense they argued, three main reasons:

First, municipal authorities have jurisdictional responsibility for the key processes (urban planning, transportation, waste collection and disposal, and energy consumption and generation) that shape GHG emissions. Not only do the authorities have the responsibility for good management of urban areas, but they also have to possess strong leadership, qualities and connections to institutional and civil networks, and in this regard the study says the following:

“According to the reports of international organizations that are studying the problem of the city and climate change, there is consensus among researchers that the capacity of urban centres to prepare themselves through mitigation and adaptation actions to climate change is linked in great extent to the quality of local governance and the strength of the institutional networks available to provide support and guidance to the inhabitants of a community. Conversely, urban areas with weak governance systems as a result of political instability, the exclusion of climate change from the political agenda or the lack of government resources, are highly vulnerable to the impacts of climate change” (UN-HABITAT, 2011, p. 87).

A second aspect is that cities concentrate a large number of people and businesses, which means that solutions for energy saving, for example, are feasible to be implemented by the local government. In other words, cities can act as laboratories where you can try and give solutions to face climate change.

Finally, the report suggests that municipal governments act as a key articulator for engagement with stakeholders from the private sector and civil society.

There is growing consensus that non-governmental actors have a key role in the fight against climate change at the urban level. Private sector organizations and civil society groups are jointly participating in a series of measures to tackle climate change independent of local and national governments (UN-HABITAT, 2011, p. 91).

In effect other authors like Castán Broto et al. (2013) say that the municipality and governments have a fundamental role in the fight against climate change and experimentation as key tools to open new political spaces and governance in the cities.

In order to mitigate CO₂ emissions to the atmosphere, local governments have emerged as important players in global efforts to mitigate greenhouse gas emissions and to enact adaptive policies to protect both people and assets. A large part of cities worldwide is incorporating mitigation actions into urban planning, which is known as climate change planning.

According to studies conducted by Aylett (2014), *Progress and Challenges in the Urban Governance of Climate Change: Results of a Global Survey*, on the incorporation of climate change planning and the number of planners who are developing this topic, it was announced that globally, 63% of cities reported they have between 1-5 professionals whose main responsibility is the planning of climate change.

The cities of North America are the ones that have reported having only one professional in charge of climate change planning and 61% of the cities reported that their mitigation plans are possible thanks to the regular contributions of other municipal agencies throughout the planning process. The two exceptions to this are Africa with 64% and Asia with 51%, where most cities reported that they are carrying out mitigation planning in isolation (Aylett, 2014).

Continuing with the study and in relation to the incorporation of mitigation and adaptation actions as an important issue, the cities surveyed reported that:

“In total 75% of cities worldwide report that they are engaging with both adaptation and mitigation. Just under 24% are focused exclusively on mitigation. The United States is the one notable exception, with 58% of cities

reporting that they engage with both adaptation and mitigation, and the highest percentage of cities conducting only mitigation planning (41%). Rather than producing isolated climate change plans, cities report that they are increasingly building climate change into other local government plans (i.e. sectoral, long range, or sustainable development plans). Canadian cities have made the most progress in this direction, while African and American cities report the lowest rates of integrating climate change into other municipal plans” (Aylett, 2014, p. 4).

The state agencies and/or private agencies that contributed the most to finance or support the management of climate change planning were the entities responsible for environmental planning and agencies in charge of land use planning, solid waste management, water and transport. The ones that contributed the least are the local electricity companies (where they exist) and the agencies responsible for health and economic development (Aylett, 2014).

According to the same authors, the three main factors that allow local governments to design and implement their mitigation strategies are leadership of the mayor or high-level elected officials, senior leadership and support of various types of local government networks, such as the Council for Local Environmental Initiatives (ICLEI). Another aspect identified by this study was the lack of synergies or general inability to effectively link mitigation actions with other urban policies of local development. There are also many cities that do not have strong partnerships either with civil societies or with the private sector.

Other identified weakness are the limited financial and human resources available to incorporate climate actions in the local governments of some cities, for example, the lack of financing for the implementation of projects and programmes is a major challenge for 78% of cities surveyed in this study.

The lack of funds to hire enough personnel to work on climate change affects 67% of the cities studied. Cities that are working to integrate climate change planning into municipal agencies report significant difficulties in incorporating climate change into existing departmental functions and procedures.

Therefore producing cultural change in local governments is not an easy task and a real challenge for almost all the municipal administrations that have been doing business as usual (Aylett, 2014).

2.3 Historical features of urban projects in Europe

In the last years the discipline of urbanism in Europe has shifted from the abstract regulatory urban approach like a traditional zoning, to a more qualitative practice that includes the notion of “urban project”. This change from the more traditional planning to an urban project, so more strategy focuses with proximity on the architecture and the rehabilitation of public space (Grulois & Crosas Armengol, 2015).

The concept “urban project”, was born out of complexity and superimposition between two tendencies in the beginning of the last century: on the one hand, the modern movements which appeared in 1920 in Germany were based on the principles of the functional city. This very radical tendency transformed the values of the cities creating another concept called the “city of the future” . However on the other hand, this was not the only direction modern architecture was taking to change cities. At the same time, innovative proposals appeared on the urban scene, which were carried out with a new approach, Dutch socialist municipalities emerged, and also new community uses in central Europe and Scandinavia, which were extremely powerful to transform the urban fabrics and manipulate the city as a field for new architecture, without losing its reference with the context. A wise discipline was born out of love for the existing city (De Solà-Morales Rubió, 1987).

Furthermore, in this period (1920) there were three questions that became the object of urban projects. One of them was the subject of residential neighbourhoods, whose schemes were a continuous testing bench through which ideas on the city were run. Another of the origins for urban projects was a civil architecture theme in the urban centre a development of Scandinavian countries, that was the first attempt to design a modern urban centre in some of their cities, with civil architecture and monuments. The urban centre became an exceptional and specific urban project.

At the same time, in all the areas covered by the “garden city” movement, greatest development would take place in a lot of countries in Europe, with a new road system layout, as a means of organizing a comfortable scale for medium-size sectors (De Solà-Morales Rubió, 1987).

According to Portas (2003), the “urban project” expression was used in the 60’s in architectural units projects inserted in high dimension projects (e.g. Team X) with the aim of representing the ideal form of the modern city from the post WWII architects’ point of view, who were against the modern urban movement.

In the 70’s a new urban project generation emerged, with specific interventions and managed by the local government which took advantage of existent cities’ frame and respected author’s architecture (e.g. Aldo Rossi, De Carlo, Solà-Morales, Bohigas, Portzamparc, Ungers, Siza and the general model IBA Berlin (Internationales Bauausstellung in German and International Building Exhibition Berlin in English). These new projects respected existent typologies and language, and promoted collective public spaces, such as squares, corners and parks.

Urban projects in the 80s maintain a taste for the city and love for its parts, two attitudes which have survived all ideological breaks since the beginning of the century. Many of the most interesting urban projects share three main themes regarding innovation, solution and approaches: roadway systems as an instrument of formalization, proposals for new fabrics and buildings, and the retranslation of urban places.

Therefore, according to the thought of Solà-Morales:

“An urban project means taking the geography of a given city, with its claims and suggestions, as a staging point, and allowing architecture to introduce language elements to give form to the site. An Urban project means trusting the complexity of the work to be accomplished more than the rational simplification of urban structures. It further means working in a inductive fashion, generalizing what is particular, strategic, local, generative” (De Solà-Morales Rubió, 1987, p. 5)

We can find the most representative urban project example in the urban renewal of Barcelona for the Olympic Games of 1992, and this new approach was being shared in different countries in Europe. This relationship between architecture and urban space was called the intermediate scale.

Moreover, we can find five points to define them as urban projects;

First, territorial effects of urban projects beyond their area of intervention; second, complex and interdependent character of their contents overcoming mono functionality (park, roadway, typologies, etc.), mixture of users, timing, and visual orientations; third, intermediate scale, to be completed within a maximum time limit of a few years; fourth, voluntarily adopted duty of carrying out an architecture of the city, independent from the architecture of the buildings; and fifth, important public components in the inversion and of community uses programmes.

Finally the urban project concept means accepting the idea of intervention as neither architecture nor plan, but as an urban project in its own right (De Solà-Morales Rubió, 1987).

A third generation of urban project is identified by Portas (2003), characterized by a higher relevance of the architects' design role, programme's development, new opportunities of the interventions, new mechanisms and tools, and the relationship between the projects and the urban plan. In this context, new concepts emerged like "Project-plan" and "strategic planning".

Since the late 1980s urban development projects (UDPs) have become increasingly popular, also in Belgium and Flanders (Belgium's northern region). By UDPs we mean physical spatial interventions that have pronounced consequences for urban development and that can act as catalysts for urban transformations. Brownfield sites become large shopping centres or green central parks, old industrial ports revitalise into creative city quarters and/or into sustainable construction sites, railway station areas transform into commercial office zones and/or stimulate sustainable urban mobility (Block & Paredis, 2013).

In the middle of the 80's and in the 90's, an international movement emerged in North America as well as in Europe with a strategic perspective in the urban development of cities. This perspective considered that cities should face pressures and opportunities to implement, the economic globalization process to increase their competitiveness (Monclús Fraga, 2003).

Big urban projects were introduced in Europe, such as the Docklands in London where public funds led private investments, applying in this case the north American framework, introducing the novel concept of leverage. This type of case is known as a “strategic urban project” (SUP) and a special, sub category among this are projects related to international events such as Olympic games or sizeable infrastructure investments.

Three are the main features of the Strategic Urban Project (SUP) as a driver of urban reality. First, the (SUP) generates a structural impact and a leverage effect in the cities’ characteristics. Furthermore, SUP has a space role and the responsibility to promote a network of actors, stakeholders, sectors and authorities, creating synergies. On the other hand, SUP mediates and organises actions, revealing multi-dimensional capacities in social, cultural and economic fields.

Third, a SUP is expected to reflect feasibility, visibility and innovation. In contrast with the modern master plan, SUP displays feasibility through time and space, allowing a medium-term approach and focusing on an intermediate scale, integrating at the same time policy makers and budget and cities’ development capabilities. To ensure this feasibility, requisite sine qua non is the intense relationship of several stakeholders and planners, especially in the planning process. Even more, creativity and innovation are required to overtake tensions and frustrations from the participation, consultation process and the inherent grey of the city.

Today the urban projects face a new challenge. The environmental issues and new normative of urban models, like the eco efficiency, sustainable neighbourhoods and smart urban block, have become the main goal (Grulois & Crosas Armengol, 2015).

2.4 The urban project in Latin America

In the decade of the 90s, the urban planning of Latin American cities experienced a crisis, mainly due to the inability to respond to the increasing deficit in infrastructures and services.

The abandonment by the practices of urban planning, dominated in the previous decades by the "director plans" and by the vision of the city imposed by the local administration, gave way to new urban policies whose objective was to reduce public intervention in all areas, especially in the planning of the territory and the land market.

Thus, through a decentralization process, traditional planning was divided into physical planning and on the other hand "urban projects" (ONU-HABITAT, 2012).

In that same period, urban operations which were known as "great urban projects" (GPU) began to be implemented in several countries. The main features of GPU are described as:

"The construction of large urban renewal operations of public initiative, through which relegated spaces of the city are transformed into "new centralities", built environments, carefully designed by large architectural studios, endowed with a high quality building and designed to house cutting-edge activities in the urban economy and high-level services: buildings for offices of leading companies, shopping centres and high standard homes, hotels for cosmopolitan tourism, convention centres, cultural spaces and brand-new recreational areas"⁵ (Cuenya, 2009, p. 229).

These projects were inserted within "urban renewal" policies which were based on the concept of urban economy in a neoliberal scheme. The aim was to shift from a manufacturing city to a service or outsourcing city. This transformation would allow urban centres to increase their competitive advantage in the global context in developing countries like Latin America.

⁵ Author's translation

To develop the services sector and associated activities in the central areas, investments were essential to build expensive infrastructure and by doing so to compete internationally.

In several cases, the State had property rights on lands with urban renewal potential and in dominant positions. On these lands, many projects were executed through a partnership between the private and the public sector. The role of the State was to promote urban operations whereas the private sector developed and invested in the building of the project (Cuenya, 2009).

Most of these projects have been carried out in developed countries, however in the developing countries, at the end of the 20th century there were only few initiatives to explicitly mitigate climate change. In most cases, these projects were managed by the municipalities through planning ordinances and indicative plans. This is the case, for example, of the principles of 'compact urban planning' incorporated in the municipal ordinances of cities such as São Paulo (Brazil), although in practice, its real effectiveness is unknown (UN-HABITAT, 2011).

Some research suggests that large-scale projects, including large urban regeneration projects, aimed at preventing urban sprawl and the reuse of abandoned lands, seem to be a more common response to mitigating climate change than small regeneration projects (Cuenya, 2009).

To be able to operate in the areas of urban renewal and to change traditional planning to a more strategic one, the "master plans" were used. The main strengths of these plans are flexibility, proactivity and a greater consensus of interests to achieve physical objectives such as the management areas of the use of land, infrastructure, transport, communications and housing.

However, the focus was on policies and regulations on land use through mixing use proposals; simple regulation and efficient responses to conflicts of interest between different urban activities, and the redefinition of standards and specifications to enable subtle changes in the functions and intensity of land uses (Burgess et al., 1997).

The great urban projects were born and shaped by profound economic, social, political and spatial transformations, which had been experienced by the majority of the world cities on since the last quarter of the 20th century. According to Cuenya (2009), these changes at a global and local level had an impact on the restructuring of built spaces and management modes, creating a new urban morphology with processes that occurred simultaneously from outside in and from the inside out (Harvey, 2004).

In the Latin American context, some cities had already reached half a millennium of existence and needed urban strategies that guaranteed their sustainability and urban development. Some had already used this strategy, developing a set of GUPs in an attempt to regenerate parts of the urban fabric degraded by obsolescence of their activities and neglected areas, producing consequences in underutilized central areas, higher levels of insecurity and landscape degradation.

In response to this, the great urban projects became fundamental pieces of urban scenario transformation and in some cases, of the construction of a city's new image (Vieira, Ito, Ashino, Yamamoto, & Deno, 2017)

In this framework, GUPs are conceived as transcendent operations not only for the strategic city positioning goals in the new global scenario, but also to counteract the economic decline of cities and increase fiscal resources.

Through the attraction of private investments, local governments intended to reactivate areas that had been relegated due to industrial decline (railway, port, airport areas in disuse) and generate urban capital gains that opened opportunities to the public sector, especially when it is the majority owner of the land up for urbanization.

This type of project was inspired by European projects carried out in several cities such as Barcelona and Bilbao in Spain which aimed to recover degraded areas and transform them into new urban centres through land management.

In general, this type of project was led by local administration using strategic planning while the execution of infrastructures and buildings was carried out, in most cases, by private investors.

In the case of some Latin American cities, river fronts were developed, such as *Puerto Madero* in Buenos Aires and *Rivera Norte* in Concepción, Chile; the re-functionalization of railway areas, old airports or industrial zones in decline, such as *Puerto Norte* in Rosario; *El Retiro* project in Buenos Aires, Tamanduatehy project in Santo Andre, Sao Paulo Brazil, or *Portal Bicentenario* project in greater Santiago Chile) or simply the expansion of zones such as Santa Fe in Mexico or the Panama Canal zone (Cuenya, 2009).

Undoubtedly, one of the most emblematic projects was “*Puerto Madero*”, in Buenos Aires, that transformed neglected areas of port infrastructure into new business, commercial, tourist and pedestrian areas.

Another example of urban renewal project was in Concepcion in Chile at the end of the 90s with the urban regeneration of the northern sector of the Biobio river. Its objective was to recover the riverbank lands that had been abandoned for years and integrate them into the city, solving social problems caused by the lack of housing and infrastructure. In this case, the State contributed with the land and a regulatory framework through a special urban plan.

In successful cases, these mega urban projects were able to produce significant changes in the structure and dynamics of urban development. However, these interventions did not have a positive impact on the social redistribution of wealth and were even negative for the most vulnerable population that occupied the area before the intervention (ONU-HABITAT, 2012).

An example of the above was the case of the *Malecón 2000* project in Guayaquil, Ecuador, which also aimed to recover lands on the banks of the Guayas river and execute an "urban regeneration" project. There was a need to create a new centrality with infrastructure and leisure and recreation facilities. This is a clear example of partnership between public and private institutions within a regulatory framework of strategic planning. Furthermore:

“In January 1997, the Malecon 2000 Foundation was created, as a private organization, chaired by the mayor and whose members were to be confirmed

by representatives of public and private institutions⁶ as well as civil society; it was responsible for planning, developing, constructing, administering, financing, and maintaining the Malecon and other areas of the city. Representatives of civil society participated, along with designers, the national government, private builders, planners, project developers, social organisations, and representatives from universities and institutions; however, there was no participation on the part of common citizens, especially of those most directly affected, street sellers and inhabitants of the area of the project and minority groups of indigenous people and beggars” (Delgado, 2013, pp. 523–524).

The urban interventions of this project were described as "exclusionary projects, a criticism of the privatization of public space, legitimized by the implementation of land use policies aimed at controlling the behaviour of the population". At the same time, the high commercial exploitation index was criticized, evidenced on "the urban marketing strategy as an instrument of power and as an instrument of consolidation of the new management model" (Vieira et al., 2017).

⁶ The main strategic partners were: Municipality of Guayaquil, Gobernación del Guayas (a representative local body of the central government), Junta Cívica de Guayaquil (civic citizenship body), universities, chambers of commerce, tourism, construction and industry organizations, foundations, and the Association of Private Banks of Ecuador”

Conclusions

In relation to the importance of incorporating and improving planning instruments and governance modes to be able to implement climate change mitigation actions, studies indicate the need for tools that incorporate climate mitigation actions through urban planning or climate planning.

The challenge for urban planners is important due to the inertia that currently exists in public bodies and local governments that must implement these actions.

The studies argue that good governance will make it possible to carry out these transformations and they suggest incorporating a top down and bottom up model with the participation of the entire community in the planning process. Governance models have also been studied, and new models or a mix of models may be discovered.

What matters is the achievement of the objectives in a short period of time, in order to be successful in the endeavours illustrated above. Several cities have created urban institutes that have helped to realize the objectives of urban planning by supporting mayors and urban planners.

It can be concluded that the figure of an urban development institute is a fundamental tool to be able to execute mitigation projects to climate change in a limited period of time.

The great efficiency and achievement of the objectives of these planning offices could accelerate the actions for the coming years generating articulations and coordination between public agencies, mayors, private developers, citizens, and urban planners.

The urban project has evolved over time and has been very important for the realization of ideas to develop urban areas in a limited period of time.

The urban project has also served to make the application of the urban policies of urban plans feasible to the scale of the city.

According to some authors, the urban project faces new challenges today; it must continue to attend to the social, environmental and economic problems of the cities

and, at the same time, join the fight against climate change, transforming into a new type of project for a new generation that must strongly incorporate mitigation actions to climate change.

In the context of Latin American cities, urban projects have influenced the urban development of several cities since the beginning of the 90s with regard to urban operations to renovate abandoned and obsolete areas.

These projects were known as GUP and could be carried out thanks to the adoption by Latin American cities of strategic planning.

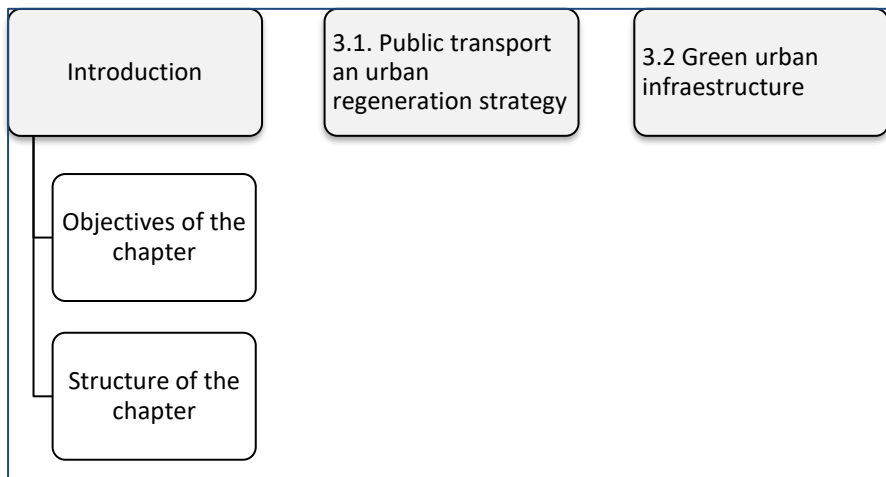
Chapter 3: Urban projects for mitigation in the Latin American context

Introduction

The aim of this chapter is to present how urban projects for mitigation in Latin American cities can be recognized and described.

The chapter is structured in two sections as shown Figure 9. The first section presents the public transport projects and urban regeneration strategy. The second section is focused on green urban infrastructure for mitigation actions. At the end of the chapter, a proposal for an integrative framework of mitigation urban project is presented.

Figure 9 Structure of the Chapter 3



Source: elaborated by the author.

3.1 Public transport projects and urban regeneration strategy

According to Cervero (2013), the new infrastructures in public transport that in the cities of developing countries, have been characterized by decentralization causing urban growth by extension, and therefore a low density in the most peripheral areas.

This is partly due to the lack of an efficient territorial planning that has allowed to extend the limits of the cities without any control, through collective transport systems that have encouraged this type of development, the Metrorail systems for example, that in Latin American cities have contributed to the segregation of households by income and class, and have displaced many poor people to the metropolitan periphery. Examples of the above can be verified in Mexico City and Santiago de Chile.

Cervero (2013), states that the Bus Rapid Transport (BRT) system will have a key role in the development of public transport, especially in medium-sized cities with a sustained population growth, and where this system is more profitable than the Metrorail.

BRT systems have been implemented steadily in developing countries, thanks to lower investment costs and construction times compared to Metrorail systems. The origins of this transportation system can be found in the following quote:

“The BRT concept originated in a few innovative cities such as Curitiba, Brazil during the 1970s. Curitiba sought to achieve rail-like quality for public transport within a limited budget. Subsequently, BRT systems have now been developed in approximately 140 cities worldwide, with notable systems in Ahmedabad (India), Bogota (Colombia), Brisbane (Australia), Cape Town (South Africa), Guangzhou (PRC), Las Vegas (United States), Nantes (France), and Sao Paulo (Brazil)” (Lindfield & Steinberg, 2012).

In 2013, there were about 160 cities that were investing in BTR systems around the world, with varied designs and typologies. Latin American cities such as Curitiba, Bogotá and São Paulo have implemented this system with great success.

Developed and developing countries with experiences like Ottawa and Curitiba suggest that when governments are proactive and take advantage of the development of mass public transport to generate urban renewal, investments in infrastructure, land use change, densification of adjoining areas, integrated neighbourhoods, services, public spaces and quality stations, we can talk about the generation of a Transit Oriented Development (TOD). The city of Bogotá is a clear example where the local government has made a proactive investment in footbridges, squares, bike paths and sidewalks nearby and connected to the BRT system called *TransMilenio* (Photograph 7).

Photograph 7: TransMilenio BRT Bogotá, Colombia



Source: Índice de Ciudades Verdes de América Latina, 2010.

Public safety and the animation of pedestrian environments have been improved, which in turn has motivated inhabitants to improve their homes and neighbourhoods. with pedestrian pathways that can encourage walking in developing cities and are important characteristics of slum upgrading programmes.

In the city of Caracas in Venezuela, in the La Vega neighbourhood, one of the largest and oldest informal settlements in the city, 30 roads have been built that cross steep hillsides to improve access to jobs, schools and health centres, encouraging walking (Robert Cervero,2013).

Authors such as Angotti et al, (2017) published a study explaining that there are BRT bus rapid transit systems in almost 200 cities around the world, most of them in Latin America.

Today, Latin American cities are facing serious problems of congestion due to the proliferation of private cars and poor public transport infrastructure. At the same time, the construction of new urban highways and metro lines with a high monetary cost and the opposition of neighbourhoods threatened by displacement continues to be privileged.

Therefore, the bus rapid transit system is a practical and relatively economical engineering and planning commitment. It is capable of moving many more people than private cars and regular buses in less time and with much lower energy and environmental costs, even if it cannot reach the capacities of urban train and metro systems.

To motivate and technically support the implementation of a BRT system in cities, a transportation institute was created in the United States:

“Bus rapid transit, bicycles, and an array of design, planning, and engineering techniques to reduce traffic, improve air quality, and make for safer streets are all part of a toolkit promoted by several organizations, including the Institute for Transportation and Development Policy (ITDP), a group that began in the United States as a small non-profit and today provides technical assistance to cities across the globe. The ITDP’s president is the former Bogotá mayor Enrique Peñalosa, who was elected again in 2015. Peñalosa was an early advocate of bus rapid transit and Bikeway” (Angotti & Irazábal, 2017, p. 9).

Since the beginning of the 21st century, the cities of Latin America are facing several challenges such as climate change, increased urbanization and the deficit of urban infrastructure for its inhabitants. It is necessary and urgent to search for a new city model that integrates both the use and occupation of urban land and a sustainable mobility system with low carbon emissions.

The big cities are working to find solutions for public transport through the metro and especially the BRT. The most successful experiences in terms of BRT have been

linked to territorial planning measures that have promoted a higher population density in the corridor environment. Along with the above, new projects are incorporating active means of transport in some cities through the construction of cycle paths and public bicycle rental systems or bike sharing schemes (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

According to McAndrews et al. (2013) carbon emissions per capita of the transport sector in Latin America are increasing faster than the rest of the world and most of these emissions come from light vehicles that operate in urban areas. In addition, the use of automobiles in Latin America is expected to grow by 300% by 2030, overtaking the effects of green transport technologies that could reduce emissions per kilometre by 30%.

Transit modernization projects can be important investments to mitigate climate change if they achieve the desired reductions in greenhouse gas emissions. Therefore, combating global warming requires a set of strategies, which include, among others, cleaner vehicles and fuels, and infrastructures that reduce the kilometres of travel by vehicle (McAndrews et al., 2013).

Public transport reforms in Bogotá and Medellín are often considered as the best practices in urban planning that emerged in Latin America at the end of the 20th century. Both serve as models for cities around the world, and are supported by institutions such as the World Bank, the United Nations and the Inter-American Development Bank. Especially, Curitiba is mentioned as innovative economic, technological and social terms on the path to urban sustainability (Tarsi, 2014).

The city of Bogotá demonstrated the benefits of the Bus Rapid Transit transport system with a study to evaluate the private and public costs and benefits of its *TransMilenio* Bus Rapid Transit (BRT) system. The economic, social and environmental benefits were evaluated through a cost-benefit analysis. The benefits were calculated by comparing the current situation with the hypothetical situation without the project over a period of 20 years (ARUP & C40, 2015).

Another important leader in the best urban practices is Curitiba, internationally recognized as a model for "sustainable" urban development. Curitiba was a pioneer in

the BRT bus rapid transit system in 1974, along with notable reforms in the management of waste, public spaces and urban design.

However, a report from the *Metropolis Observatory* indicated that the metropolitan region of Curitiba was the most motorized among the 15 regions observed in 2012, with 49.8 vehicles per 100 inhabitants.

To solve the above and complement the existing mobility strategy, the Curitiba Eco electric project began to be implemented, which will allow the city to reduce greenhouse gas emissions related to transport, with the aim of moving towards a low carbon transition economy reducing the dependence on fossil fuels.

This project is a pioneer in Brazil and could inspire other cities in the country and Latin America to invest in electric mobility, as long as the electricity grid is based on renewable sources, such as a hydroelectric or renewable energy plants (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

3.2 Green urban infrastructure for mitigation actions

During this millennium, cities and their peripheral areas will face new challenges due to climate change. Floods caused by heavy rainfall, droughts, heat waves and hurricanes, could put human life and the environment at risk in cities in developing countries and threaten the comfortable urban life that many cities offer today, especially in more developed countries.

One of the earliest uses of the term infrastructure was applied twenty years ago to define parks and green spaces (Rosenberg, 1996), with the intention of redefining the public park as an extension of urban infrastructure. The use of the term *infrastructure* separates parks from amenity functions, and was intended to raise an integrated set of large-scale, city-wide public works functioning as investments and/or assets, and deployed primarily for human benefits like transport, waste water, storm water or energy infrastructure (Matthews, Lo, & Byrne, 2015).

According to Matthews et al (2015) green infrastructure (GI) has since become an important object of scholarly inquiry. Green infrastructure typically refers to an interconnected network of multifunctional green spaces that are strategically planned and managed to provide a range of ecological, social, and economic benefits (Benedict & McMahon, 2006; Kambites & Owen, 2006; Tzoulas et al., 2007; Wright, 2011).

Some examples of green infrastructure are green roofs, permeable vegetated surfaces, green alleys and streets, urban forests, public parks, community garden and urban wetlands. (Douglas, Goode, & Wang, 2010)

Matthews et al point out that scholars recognize that green infrastructure can potentially improve residents' health and wellbeing, provide food, lower wind speeds, reduce storm-water runoff, modulate ambient temperatures, reduce energy use and capture carbon, among other ecosystem service benefits (Matthews, Lo, & Byrne, 2015).

However, there are difficulties with how spatial planners and built environment researchers have defined and operationalized the term green infrastructure. For

example, the term has tended to be conflated with 'green-space' generally, weakening its conceptual strength (Benedict & McMahon, 2006).

Some cities are addressing this problem to face the new challenges, through the mitigation potential of the green and blue spaces, known as the green (and blue) infrastructure (GUI). Green urban infrastructure is recognized as a hybrid infrastructure of green spaces and built systems, e.g. forests, wetlands, parks, green roofs and walls that together can contribute to ecosystem resilience and human benefits (Naumann, Davis, Kaphengst, Pieterse, & Rayment, 2011a); (Pauleit, Liu, Kazmierczak, & Kazmierczak, 2012).

Green urban Infrastructure can complement natural areas, providing habitats for diverse biota that can help to protect terrestrial and aquatic ecosystems (Ignatieva, Stewart, & Meurk, 2011). On the other hand, Naumann et al (2010) highlighting the need for: "a holistic and more integrated approach view of functions from nature conservation to social benefits, including benefits for coping with climate change, for citizens from regional to city (neighbourhood) and site-specific scales" (page 108).

Other authors are saying that green urban infrastructure may reduce the adverse effects of climate change in urban areas. In effect, these constructions balance water flows to alleviate flooding, providing thermal comfort by shading vegetation, and provide people with opportunities to grow food for themselves (Cameron et al., 2012; Farrugia, Hudson, & McCulloch, 2013; Krasny & Tidball, 2009). Furthermore, "green urban infrastructure has also gained attention as a resource for mitigating climate change, e.g. its biomass can function as carbon storage" (Davies, Edmondson, Heinemeyer, Leake, & Gaston, 2011).

In the last decade, in scientific meetings on climate change mitigation and adaptation, green urban infrastructure has often been related with policy and governance (Naumann, Davis, Kaphengst, Pieterse, & Rayment, 2011b), albeit less holistically based on empirical evidence of benefits and costs. Since ten years ago, the services and benefits of green urban infrastructure to climate change mitigation and adaptation have been studied (Gill, Handley, Ennos, & Pauleit, 2007; Laforteza, Carrus, Sanesi, & Davies, 2009) and conceptual frameworks have been developed to create services and benefits in multi-scale contexts.

Green urban infrastructure contributes to climate change mitigation by removing CO₂ from the atmosphere via photosynthetic uptake during the day and releasing CO₂ at night via respiration, while additional uptake can occur via below-ground biomass and soils (Velasco & Roth, 2010). Therefore it is possible to consider all sink sources in the urban areas, that can capture the net urban CO₂ in the atmosphere. Talking about Leicester in the UK, Davies et al. (2011) indicated: “the total average carbon stored within the above-ground vegetation across the city to be 31.6 t C per ha⁻¹ of urban area and 7.6 t C ha⁻¹ alone for domestic gardens”.

According to Demuzere, (2014), green urban infrastructure can play a role in climate change adaptation through reducing air and surface temperature by providing shading and enhancing evapotranspiration, which leads to two benefits: reduced energy use and improved thermal comfort.

The thermal comfort can be measured through physical indicators such as ambient temperature, winds fluxes and energy savings (Demuzere et al., 2014).

Bowler et al. (2010) concluded that, considering green urban infrastructure for different places across the world, that surface temperatures of green roofs are cooler than non-green roofs, although the actual difference changes according to the time of day, season and climatic conditions. On the other hand the volume of water stored in forests, wetlands and floodplains are characterized by buffers of peak flows and they also purify water through pollutant removal. These services are relevant to urban areas for adapting to changing weather patterns and the dynamics of human requirements (Farrugia et al., 2013).

Green urban infrastructure has an important role in controlling rain runoff; like the Manning's equation indicates, runoff in urban areas has greater velocity due to smooth impervious surfaces compared to rough natural surfaces (Jacobson, 2011). Indeed, while up to 60% of rainwater becomes runoff in vegetation-free cities, vegetated areas retain between 5 and 15%, thereby reducing peak discharge and inducing groundwater recharge.

However, according to (Ellis, 2012; Gill et al., 2007) effective functioning of green infrastructures depends on their location in the urban landscape, that should consist of a combination of corridors and patches of areas with soils that have a high infiltration capacity; e.g. in the highly flood prone urbanized *Lake Como* catchment, green areas have reduced storm water runoff up to 100% during normal precipitation years and 88% during high precipitation years. At the same time green urban infrastructure help to improve air quality through the absorption of pollutants like particulate matter (PM₁₀).

Some of the particulates absorb light and are called *short lived climate pollutants* (SLCPs) such the case of black carbon. Urban vegetation absorbing SLCPs has a positive effect on climate change mitigation. However, there is only a limited amount of empirical evidence available and this is mainly related to roadside vegetation Brantley et al. (2014) have verified reductions in black carbon (indicating traffic exhaust) behind the vegetation barrier, although, they did not see changes in coarse or fine particle levels.

Furthermore, green urban infrastructure has health benefits because it increases inhabitants' participation in physical and social activities, relaxation, comfort and satisfaction (Mansor, Said, and Mohamad 2012). Some studies indicate that green urban infrastructure encourages more active and healthier forms of travel such as walking and cycling (Coombes, Jones, and Hillsdon 2010) and as a result can help to mitigate climate change as it can reduce carbon emissions.

Good access to urban green spaces is associated with higher physical activity levels, and a lower likelihood of being overweight or obese (Coombes et al., 2010), and there is furthermore a relationship between green urban infrastructure and lower levels of anxiety disorder and depression, for children and people with a lower socio-economic status. Illness or impairment are considered as an impediment for taking adaptive measures in case of climate extreme (Tzoulas et al., 2007).

In this sense the vulnerable social groups could benefit from the possibility of having better health and extended recreative spaces offered by green urban infrastructure in response to climate change effects (Demuzere et al., 2014). On a smaller neighbourhood scale green spaces with the trees create shade in the street or in private gardens which enhance health by mitigating stressful life events, especially at

times of social and environmental perturbations (Van den Berg, Maas, Verheij, & Groenewegen, 2010).

According to Mathews et al (2015), spatial planners are facing three key challenges regarding green infrastructure: first, difficulties in conceptualizing green infrastructure, second, problems with containing green infrastructure within planning tools and processes, and finally challenges in employing green infrastructure for climate change adaptation (Matthews, Lo, & Byrne, 2015).

Green urban planning is important, both to maintain natural ecosystems in cities and to restore them taking, into account the value of the ecosystems inside the territory. In effect Benedict et al (2006) points out that is very important to consider green infrastructure within urban planning, and argue that:

“just like our built infrastructure, our green infrastructure should be carefully planned, designed, and invested in far in advance of development. Green infrastructure planning should be the first step in the land-use planning and design process. Green infrastructure planning should also be coordinated with planning for gray infrastructure-roads, bike trails, water, electric, telecommunication and other essential community support systems. Integrated planning and design should connect the two in a more effective, economic and sustainable network. Green infrastructure initiatives should use approaches similar to those used for the planning, design and financing of built infrastructure” (Benedict & McMahon, 2006).

In this sense, the green infrastructure movement is essentially an economic case for greening (Horwood, 2011). For planners, the attraction of green infrastructure is its great potential to move beyond conflicting debates about continuing growth and land conservation (Horwood, 2011; Wright, 2011).

Poli and Ravagnan emphasized the international debate about of the fundamental role that urban planning should take on fighting the effects of climate change, (especially urban and territorial regeneration), and the relationship whit green and blue infrastructure systems for the creation of a new city model (Poli & Ravagnan, 2017).

As Bendict and McMahon (2006, p. 58) argue:

“communities that want more housing, more jobs, and more open space can use green infrastructure to achieve all of these goals”.

According to Matthews et al, (2015) the green infrastructure approach supplies a thorough framework to accommodate competing interests and to engage environmental objectives and dominant economic imperatives. This approach is integrative as well as pragmatic, involving attempts to ecologically modernize the concept of urban green space in economic terms as well as attracting urban planners to collaborate in the planning process (Matthews, Lo, & Byrne, 2015).

The author goes on to say that managing green infrastructure for climate adaptation is mainly about managing risks or uncertainties created by human impact. The risk-based approach to climate change has three important aspects: problem framing and role, embedded policy debate and planning approaches.

The first problems associated with adverse weather conditions, including rainstorms, floods, heat waves and hurricanes, tend to be understood in probabilistic terms.

Second, the concept of green infrastructure is embedded into a policy debate that is prudent toward mainstream policy imperatives. Traditional progressive growth models have in the long term contributed to human-induced climate change, which is an outcome of uncontrolled industrial and urban activities producing excessive quantities of greenhouse gases. The role of green infrastructure then is to cope with the adverse side-effects of unchecked economic growth, rather than to promote it. (Matthews, Lo, & Byrne, 2015)

The third defining aspect of a risk-based approach to climate change relates to planning approaches. In this regard, Dryzek argues that rationalist approaches are ill-suited for managing system uncertainties (Dryzek, 1987). He says that:

“A lack of precision is inherent in the prediction of extreme weather events. The ecosystem based adaptation approach shows us that the cost of maintaining green infrastructure for mitigation of disaster risks may be less than the

construction of grey infrastructure to adapt to global climate changes” (Matthews, Lo, & Byrne, 2015).

Green infrastructure can also be defined as an element that enables the development of ecological relations between the city and its environmental context, whilst catering for social needs that are fundamental for the attainment of a high standard of urban life (Tulisi 2017).

Specifically, green infrastructure refers to the development of urban green spaces, such as parks, rain gardens, and greenways, that provide a variety of social and ecological benefits, from improved public health to storm water abatement (Meerow and Newell 2017).

Green infrastructure can also be viewed as simultaneously providing natural resource sinks to assist urban climate control and water management and provide important green networks in an increasingly urbanised territory. Green infrastructure planning is more a synthesis of different planning approaches than a completely new approach (Mell 2009).

Finally green infrastructure is a concept for systems that provide multiple ecosystem services in urban areas. Green infrastructure is often a hybrid of built infrastructure and man-made ecosystems as is the case with storm water wetlands that process highway drainage, or bicycle corridors that provide wildlife habitat and connectivity (Ahern 2013).

3.3 Green spaces projects in Latin America cities

Nearly 13 million inhabitants are living in the greater metropolitan region of Rio de Janeiro. Brazil's 2010 census estimated that 22% of the population lived in informal settlements that have not much access to green space. While Rio has some large parklands in the city they are concentrated in rich areas and inaccessible to common people (C40 & ARUP, 2015).

This absence of green space in more disadvantaged areas of the city has had serious consequences for the inhabitants, especially as temperatures increase due to climate

change. Urban heat island effect combined with the tropical climate of Rio, mean that temperatures can become extreme in these neighbourhoods. To address this issue and to help improve the public space of these parts of the city, Rio de Janeiro has adopted policies aimed at improving the distribution of green space.

Despite this there is a mind-set in the city that actively opposes the introduction of trees because the people think that they obscure their view, or they will advocate for public squares, but not want those spaces to include trees or other greenery. The people even threaten to cut down trees or branches. It is true that green spaces add a lot of quality to wellbeing and urban environment, but there are parts of the population that do not understand these ideas (C40 & ARUP, 2015).

However, the municipality of Rio had worked to demonstrate to the inhabitants the benefits of the green spaces before building the urban park. In fact the evaluation process used for this kind of policy made it very difficult to demonstrate to the community and the council what the gains would be. The city needed to be better able to articulate what it means to have a green city, and how it is beneficial to residents (C40 & ARUP, 2015).

Rio de Janeiro constructed Madureira Park, which was inaugurated in June 2012 and has already become the third largest park in this city, with an area of 109.000m² located in one of the most built up areas of Rio. The park provides recreational areas for the nearby residents twenty-four hours a day and has a lot of facilities. The park has been developed to minimise its environmental impact and includes facilities for harvesting storm water runoff and solar panels for the visitor centre.

The park has also created benefits for nearby residents by lowering the temperature in surrounding areas by about 2 degrees Celsius, which has a strong impact on energy consumption (e.g. air conditioning). The local community is very satisfied with the new park, and the quantity and quality of facilities available incorporated co-benefits that the people have the possibility to enjoy. Sport activities and a healthier way of living are promoted (ARUP & C40, 2015).

Other cities like Bogotá are realising a project sustained to conserve its local biodiversity and promote the increase and interconnection of green areas in the city.

The technical support of the Botanical Garden and the leadership of the District Secretary of Environment, has been very important in three years 32,368 m² of green roofs and vertical gardens were inserted into the urban landscape, as a result of the incentive policies directed toward citizens and the private sector (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

The effort for the integration of the blue-green infrastructure in the territory planning in Latin American cities is still incipient, but the experiences with urban gardens, green roofs, linear parks and navigability of waterway are multiplying. It is very important and urgent to value them both because of their ecosystem services and because they are key players in urban planning (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

Conclusions

In the last 10 years, many researchers have been studying the relationship between cities and climate change and how mitigation actions can be implemented.

The need to incorporate climate change planning, and the urgency that governments at all levels and above all local governments through their mayors are the leaders of this process has been theorized.

Studies have also insisted on the need to include all citizens in this activity (Paloscia & Tarsi, 2012) as well as public and private institutions in this activity. Until now, the relationship between planning, urban infrastructures and land use have been studied as key elements in the fight against GHG gas emissions.

It is also important to note that several and multifaceted elements are participating around the urban projects in a scale of a place, city or a region. “The adding up of the natural, built and anthropic environments defined through a co-evolutional process very much similar to that a very complex living organism” (Paloscia, Morbidoni, & Spellucci, 2017, p. 23) is called the “Territorio” (in Italian), a concept belonging to the “territorialist school” of Florence. Another concept of the cited school is the Self-sustainable local Development (SsLD) that gather environmental cultural, social, economic and political sustainability features (Magnaghi, 2005).

While urban planning can help cities better prepare for the effects of climate change, it is urban projects that will actually be able to carry out these actions.

An urban project according to Manuel de Solà Morales, moves between the scale of architecture and the scale of the city, and is able to operate on strategic points of the urban fabric of a city.

Urban projects originated in Europe as long as one hundred years ago introduced in Latin America in the late 1980s and early 90s accompanied by strategic planning.

Some Latin American cities were strongly influenced at the end of the last century by the urbanism of the modern movement, especially by master plans and their influence on the culture of urban planners, and this remained until the end of the second half of

the past century, when it gave way to a new generation of urban plans, urban regulatory plans and urban development plans or urban strategic plans.

Along with these, they begin to develop a series of urban projects on different scales and with different strategies that sought at that time to improve the quality of life cities dwellers.

There are some emblematic examples like the city of Curitiba, and successively Bogotá and Medellín, with their citizen participation programmes, and Quito, Ecuador, which have been working on their respective projects to achieve better cities for their inhabitants.

Some of these projects were oriented towards the development of a cheaper and more integrated mass public transport medium, which not only solved a transport problem but also incorporated urban renewal in the peripheral areas thanks to this type of transport.

The first BRTs were inaugurated which, added to the urban land use strategies, were known as Transit Oriented Development (TOD), and the first cable-cars made it possible to implement integral urban projects as a way to regenerate a neighbourhood that was socially very depressed, as in the case of Medellín.

Other projects belong to what are now known as green or blue infrastructures, and refer to projects in predominantly non-urban areas adjacent to lakes or rivers that serve to mitigate natural risks due to floods or heavy rains. In other cases they are mitigation projects of basins or streams that serve to mitigate landslides but also incorporate public spaces and cultural facilities.

All these projects belong to a fourth generation of urban projects that incorporate mitigation actions to climate change. On the one hand they avoid releasing GHG emissions to the atmosphere and synergistically regenerate or renew urban areas for the benefit of the inhabitants.

On the other hand, we see projects that are related to mitigation actions against natural risks that also incorporate urban recreational facilities.

Finally we can conclude that there are two types of urban mitigation project:

The first typology corresponds to projects that reduce CO₂ emissions to the atmosphere using energy from renewable sources, for example, hydroelectric power stations or wind energy, and/or that capture CO₂, for example, urban reforestation projects.

A second typology of projects are those that mitigate the risks of natural disasters caused by climate change, incorporating vulnerable areas such as lakes, river banks, and streams, which can additionally be used as parks or green corridors with leisure facilities for the inhabitants of the cities.

Both project models must be incorporated into an urban plan that ensures the change of land use for urban regeneration or necessary urban renovations of vulnerable areas.

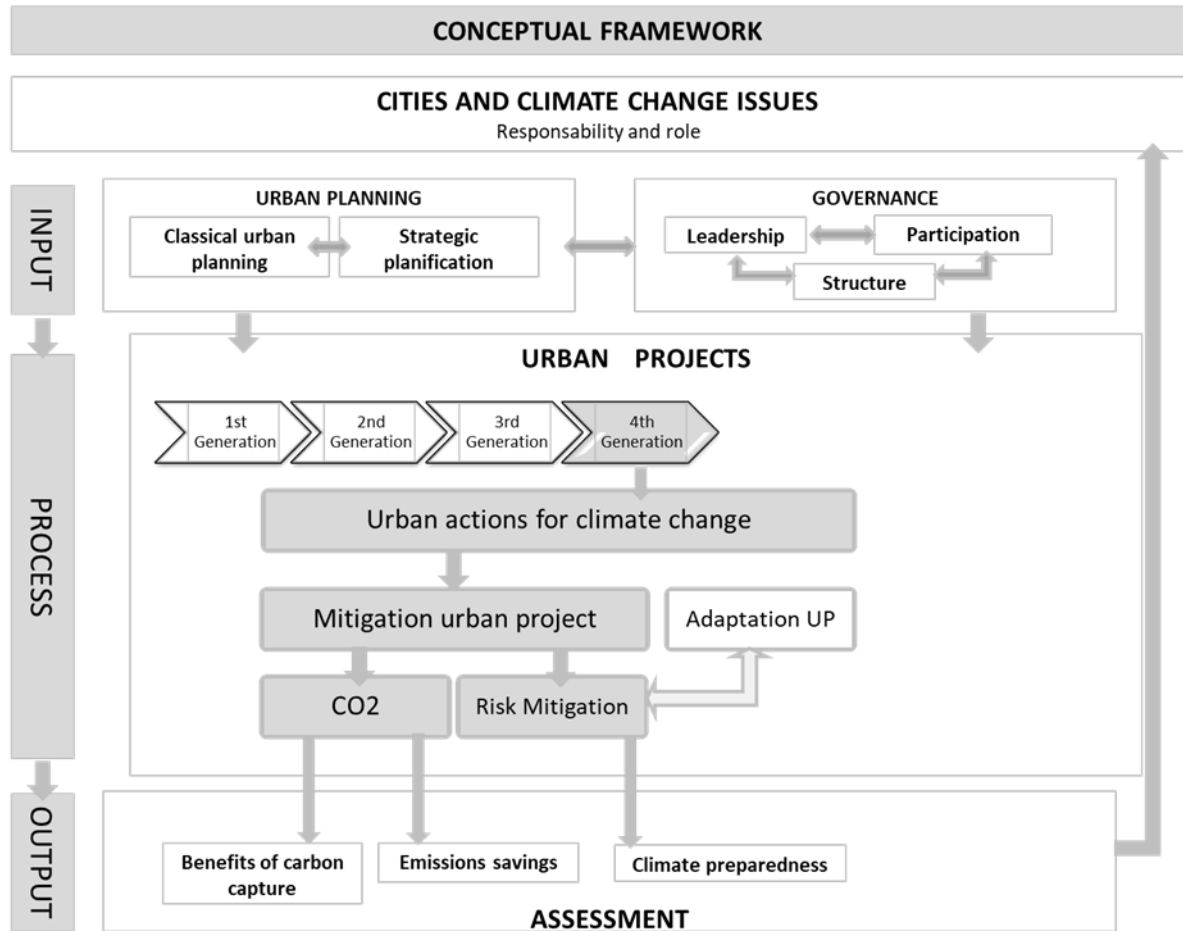
And finally, it must be a participatory project incorporating both top down and bottom up models and having an urban institute and a strong leadership from the mayor that allows these actions to be extended over time.

Taking into account the literature about climate change in relation to cities, urban planning and urban projects in the context of mitigation, a definition is needed to be used in this scenario of a fourth generation of urban projects, complementing Portas (2003) contributions. In a process perspective, it is possible to recognize that some dimensions are present in cities to enable the implementation of urban projects as urban planning and governance.

Both are at the origin of an urban project and the implementation or process step can be understood in terms of this fourth generation of urban projects that are facilitating urban actions for climate change. These actions can operate in two levels: as mitigation urban projects and adaptation urban projects. In the case of mitigation urban projects, the outcomes are focused on CO₂ reduction and risk mitigation. Adaptation projects can also be linked with risks mitigation. Then, focused on the outcomes of this fourth generation, the benefits of carbon capture and emissions savings can be obtained and so can preparedness. This conceptual proposal is shown in Figure 10. Thus, the mitigation urban project is a new generation of urban project (the fourth),

that can be defined as an urban project that assumes climate change actions with mitigation potentialities at a city level scale.

Figure 10: Conceptual framework



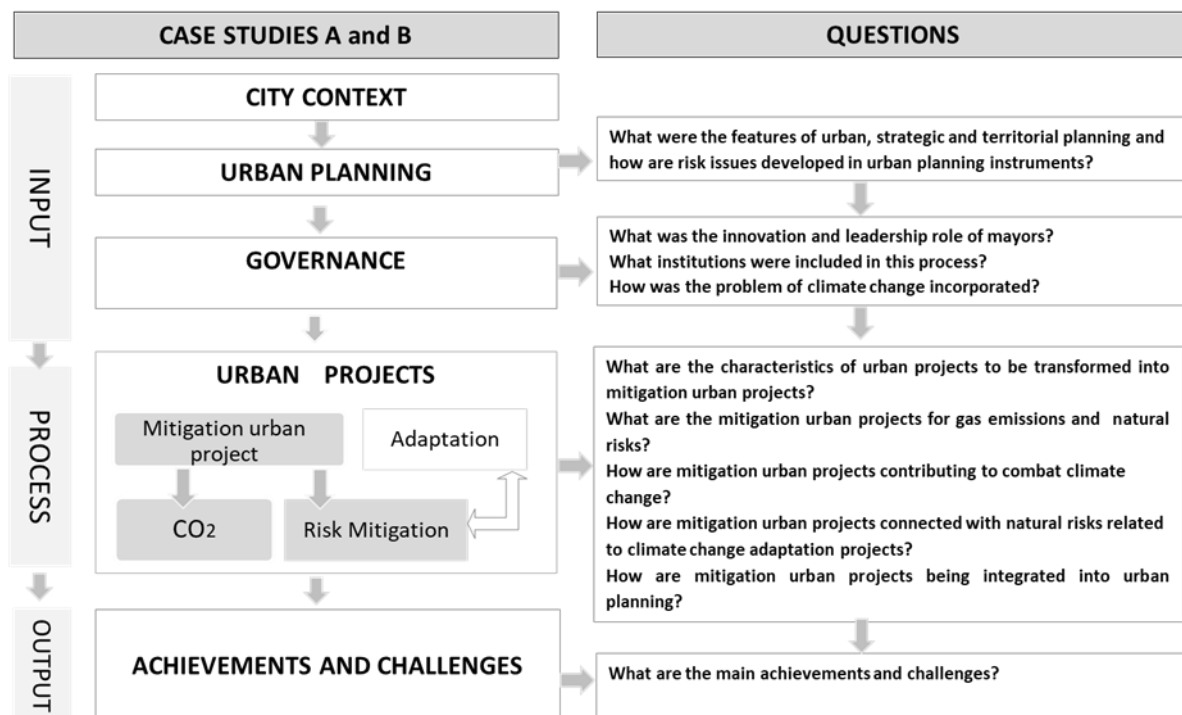
Source: elaborated by the author

Chapter 4 Case studies: Curitiba and Medellín

Introduction

The aim of this chapter is to operationalize the conceptual framework, presented in the previous chapter and conduct the analysis of two cases studies, Curitiba and Medellín. According to the framework, the main concepts of city context, urban planning, governance, urban projects and achievements and challenges lead to several questions that constitute key aspects that should be observed in each case. The same pattern of analysis facilitates the comparison of cases at the end of this chapter. This design is expressed in Figure 11. At the end of the chapter a comparison of the findings between cases are presented followed by the conclusions of the chapter.

Figure 11: Case study design



Source: elaborated by the author.

The research design is a case study with multiple cases belonging to different contexts (Yin, 2009). The selection of the case study depends on the problem formulation and literature review findings, so they could be significant and interesting. Cases are chosen and then the data collecting instruments that are qualitative or quantitative, are determined the cases are analysed separately and then commonalities or differences in terms of the research questions are identified to obtain conclusions.

Related to geography, both cities are located in internal regions of south America without costal landscapes. Medellin is located at 1500 m above sea level and Curitiba in a plateau at 932 m above sea level. Medellin has a humid subtropical climate and Curitiba a subtropical highland climate. Both register high levels of rainfall and raging rivers. They represent medium and big sized of cities with more than a million inhabitants.

In terms of historical context, both cities share a similar colonial legacy in the New World at the beginning of the 17th century. Curitiba in Brazil was built under the Portuguese Empire and the Spanish crown founded Medellin in Colombia. Through time, these cities experienced significant growth due to the economic welfare and played an attracting role for new migrants. This continuous growth was managed in a reactive way with short term urban plans. The performance of this planning style and its results have been recognized as an important contribution to the urban development and it has received several awards.

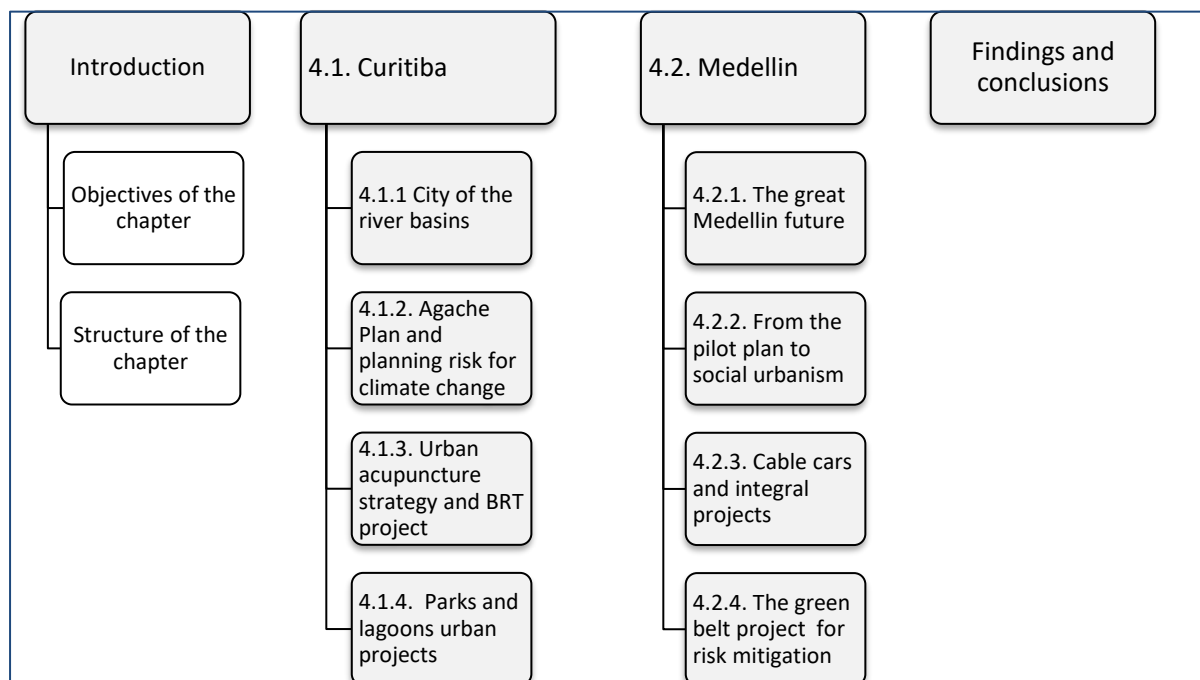
In terms of urban planning in the 1940's, the influence of urban modernism (long term projection) is evident in both cities. They declared a city vision through planning instruments and evolved from a traditional planning to a modern planning, then a strategic planning and finally a territorial planning.

In the governance arena, both cities were headed for long periods by mayors with strong leadership and were supported by internal urban management offices in charge of planning and urban projects. At the beginning of transformations, Medellin operated with a bottom-up system of governance and on the contrary Curitiba initiated with a top-down strategy.

Related to urban projects, both cities developed mitigation projects for the reduction of CO₂, focusing on mass public transport, reforestation and protection of natural areas with mitigation of natural risks, thus facilitating in this way climate change projects.

The first section presents Curitiba and the second Medellin, as expressed in Figure 12. Conclusions are presented for each case and finally comparisons are explained.

Figure 12 Structure of the chapter 4



Source: elaborated by the author.

4.1 Curitiba; Introduction and Methodology

The 1992 World Summit on Sustainable Development took place in Rio de Janeiro. At that meeting Curitiba was internationally acknowledged, together with two other cases, as an example of an eco-city initiative (Joss, Tomozeiu, & Cowley, 2011). By then Curitiba could boast a considerable experience in its attempt to become a sustainable city. It had been able to develop some remarkable initiatives such as a public transport system, processes of urban rehabilitation and land use management and creating culturally interesting public open spaces with cultural facilities as well as creating areas of natural protection within the metropolitan region.

Today Curitiba is recognised as one of the cities with better life quality in Latin America, one of the more ecological compared with other cities of the same size, and it is a city famous for sustainable development supported by an efficient public transport system based on exclusive corridors known as *bus rapid transit* or BRT (Siemens AG, 2010).

All these achievements have been possible thanks to long term planning which began with the first urban plan, approved in 1943 and actualized in 1965 with a second urban plan that started to materialize in the decade of the 70s under the administration of Major Jaime Lerner, and also thanks to the creation of the Curitiba Research and Planning Institute (Peña Flores & Escudero Peña, 2001).

During the 80s and 90s Curitiba continued implementing projects aimed at achieving a more sustainable city through the building of segregated roads for public transport completing five corridors that connect the city on a radial scheme, the building of public urban parks using water rain providing them with cultural facilities together with community programmes for garbage disposal and recycling. In the year 2004 the city's Director Plan was revised and, the general outlines of the 1965 Plan was maintained. However more participative instances were incorporated in the planning process contrasting with the top-down approach of the previous management period.

In the year 2005, Curitiba's local government started to develop a vulnerability diagnosis of environmental fragility as a result of a possible scenario of flood risks. A risks map for the metropolitan area of Curitiba was drawn. Today such problems are being approached in two different ways. On one hand the transport system is being

improved by the opening of a new Green Line corridor introducing a number of hybrid buses and on the other hand, the urban park system exists as a way to control flooding, which together with the river branches and small lagoons serve not only as recreational spaces but also as mitigation projects, to achieve a city more resistant to confront climate change for the next 60 years (Lindau, Hidalgo, & Facchini, 2010).

The methodological proposal to address this first case, considers the following dimensions:

Firstly, the historical process of the city and Curitiba's urban planning is described with existing government approach to the planning process in the creation of a parallel institution to the Municipality for urban planning. The projects implemented in Curitiba are also described. They are a referent of good practices and show how these projects are helping in the mitigation of climate change effects.

Secondly, it is worth revising the two groups of projects being developed. One is oriented to mitigating CO₂ emissions to the atmosphere, the transport system, urban tree-planting, reforestation of natural protection areas and the implementation of a hybrid transportation system. The other is directed to mitigating the effects of natural disasters caused by catastrophic rainfall, the urban parks and public spaces system.

Finally, the chapter will conclude with the achievements and challenges that this case puts forward and their possible implications and applications in other urban situations by big cities with similar urban problems resulting from climate change.

4.1.1. The city of the river basins

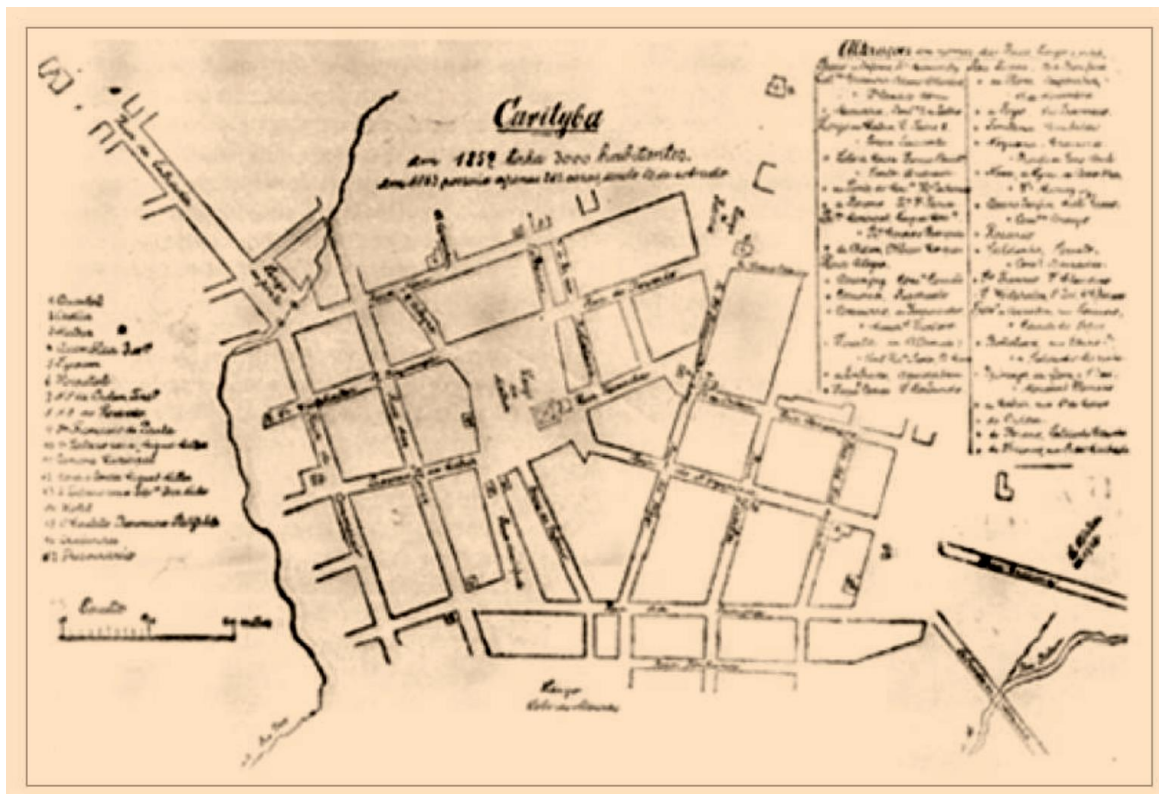
Curitiba is located in South Brazil with 1.9 million inhabitants approximately (IBGE, 2017). Curitiba is the capital and largest city of the State of Paraná. The Curitiba Metropolitan Area (RMC) comprises 29 municipalities with a total population of over 3.5 million (IBGE) covering an area of 435 km². The city lies in a temperate zone and is located on a plateau of 934 meters above sea level with an average minimum temperature of 7°C in the coldest month, occasionally falling below 0°C on the coldest nights. During summertime, the average temperature is around 25°C in the daytime, but it can get above 30°C on the hottest days. There is an annual average of 1.500 mm of rainfall (IPPUC, 2014).

The Curitiba's Metropolitan Region is crossed by six hydrographical basins: the basins of the Passaúna, Barigui, Ribeirão dos Padilha, Belém and Actuaba rivers and the Iguazú River basins. The municipality of Curitiba is on the right side and to the east of the biggest basin of Paraná River, the hydrographical basin of the Iguazú River (Curitiba, 2018).

Curitiba was founded on 29 March 1693 under the name of Vila de Nossa Senhora da Luz dos Pinhais, but in 1721 was renamed as Curitiba. In 1853, it was designated as the capital city of the state of Paraná (Figure 13). During the second half of the nineteenth century as a result of economic growth and workers' migration, urban growth increased. In 1857 the French engineer Pierre Taulois was hired to propose a new urban lay-out, with an orthogonal design and the implementation of public works. On 2 May, 1866 the Park Vila de Nossa Senhora da Luz dos Pinhais, the first urban park, was inaugurated with the aim to make it a public promenade as well as the first public sewage system.

By the year 1913 Curitiba was continuing its urban transformation, mainly roads paved with stones, while old trams pulled by mules were replaced by electric ones and a new housing policy was implemented. During the 20s and 30s, the city increased its rapid growth, and the most noticeable aspect was the opening of new roads and the paving of the majority of them (Peña Flores & Escudero Peña, 2001).

Figure 13: Curitiba 1853



Source: (IPPUC, 2014).

4.1.2. Agache Plan and Planning risk for climate change

During 1943 the Municipality of Curitiba contracted the consultants Coimbra Bueno & Cia. Ltda of Rio de Janeiro who together with French engineer Alfred Agache, proposed a new design for the future growth of the city known as the Agache Plan (Figure 14), a radio-concentric model which allowed to define the areas of expansion, land use for housing, services and industry, road restructuring and land improvement. In the case of Curitiba,

“[...] the Central radio concept, establishes a system of hierarchical roads, by radial and perimeter avenues, defines a zoning of functionally specialized areas and implements a series of sanitation measures that go from the creation of new parks for the purpose of construction of dams in the rivers to the attention with the infrastructure, the drainage and the normalization of the constructive aspects. Established constructive parameters for buildings and sanitary guidelines such as drainage in the frontal recoil area[...]” (IPPUC, 2014, p. 21).

Figure 14: Plan Agache



Source: (IPPUC, 2014).

The Plan also proposed the construction of governmental buildings as well as cultural centres, one of which is the civic centre that houses, federal and local institutions, built in 1952 with a modern architecture design. By that time the inhabitants of Curitiba were 180,000. The Agache Plan was surpassed in its projections by the intensive population growth that reached a rate of 5.3% during the 50s and 60s.

This growth was principally the result of the immigration from the interior of the country, made more acute by the mechanization of the agriculture that displaced many farmers. In 1955 the first stage of a System of Massive Transport for Curitiba was implemented, and the authorities of that time realized the need to redesign a new urban development plan (Irazábal, 2009).

a.- The Master Plan of 1966

In 1964 through a national selection the Preliminary Plan of Urbanism was born, which proposed a linear model of urban expansion. This Plan arose from the need to

create an industrial area. The Curitiba Research and Planning Institute (IPPUC), formerly the Curitiba Research and Planning Office, was formed in 1965 to supervise the application of the Plan proposed by the Serete Society and Jorge Wilhelm Architects, who had won the national tender.

The Master Plan was approved by Law N. 2.828/66, was carried out by Journal on August 16, 1966. The creation and elaboration of the Master Plan was under the responsibility of the Curitiba Institute for Research and Urban planning, (IPPUC in Portuguese). This Master Plan was an important instrument for the urban policy of the city and had the purpose of managing the planning of the city's urban growth and balancing its social and economic development.

This plan was discussed by the population in a series of public debates, but only from 1971 it passed from the theory to the practice, with the definition of three basic changes in the city: the physical, the economic and the cultural transformation. The philosophy adopted by the plan was of integrating the functions of housing, work, transport and leisure into the urban services, from a tripod system composed of transport, road systems and use of the urban soil. In Serete's project the principal arteries of the city were established, the big North-South and East-West routes. The IPPUC team perfected the idea with the ternary system: a central exclusive corridor for collective transport and two parallel bi-directional axes, one for the rapid traffic and other one for the slow traffic. The ternary system allowed the creation of the first BRT system of the country in 1974 (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

In 2004, the Master Plan was updated by IPPUC which supervised, coordinated and monitored the process. In this process, inhabitants, main users of the urban space, managers, universities, social representatives and municipality were invited to participate through public audiences (PLAN DIRECTOR, 2004, p.62).

The Master Plan of Curitiba established as guidelines: the urban development policy of the municipality; Urban-environmental policy on basic sanitation and water preservation; social and economic policy and democratic management (PLAN DIRECTOR, 2004, p.66).

The urban-environmental policy refers to the rational use of the territory, considering its vocation, infrastructure and natural resources, by controlling the implementation and operation of activities that have an impact on the environment urban environment, and proposes the areas of environmental preservation (PLAN DIRECTOR, 2004, p.69)

In the year 2001, by means of a federal law, all the municipalities of cities with more than 20 thousand inhabitants were instructed to develop their Master Plans. In the case of Curitiba, the city already had the Master Plan of 1966, but due to the new guidelines on the development of the cities and the new challenges, when the Plan was updated in 2004, emerged several Sectorial Plans emerged,, one of which was the Sectorial Plan for sustainable development and environmental control.

b.- Planning risk and climate change

Due to the concern for the future effects of climate change and how they affect urban functions, the municipality proposed a climate change programme whose strategy was to "develop and apply a policy aimed at mitigating greenhouse gases in a local level" with the objective of: "reducing the emission of greenhouse gases at the local level; protect and increase CO₂ sinks and greenhouse gas deposits" (Curitiba, 2018).

In 2013, the municipality of Curitiba was selected to participate in the project "Promoting Low Carbon Urban Development Strategies in Emerging Economies (URBAN LEDS) in association with ICLEI - Local Governments for Sustainability, UN-HABITAT and funded by the European Commission".

In 2016, the prefecture of Curitiba through the municipal secretary of environment, released the report on greenhouse gas emissions for the period 2012-2013. They were distributed by areas and transport is the largest producer of CO₂ gases with 75%, followed by power stations with 12%. It is planned for the next measurements to incorporate more variables in the use of private vehicles, due to the dispersion in the metropolitan region.

This report also incorporates a programme of "Evaluation and quantification of carbon absorption potential", known as sinks. The absorption potential of urban parks, natural

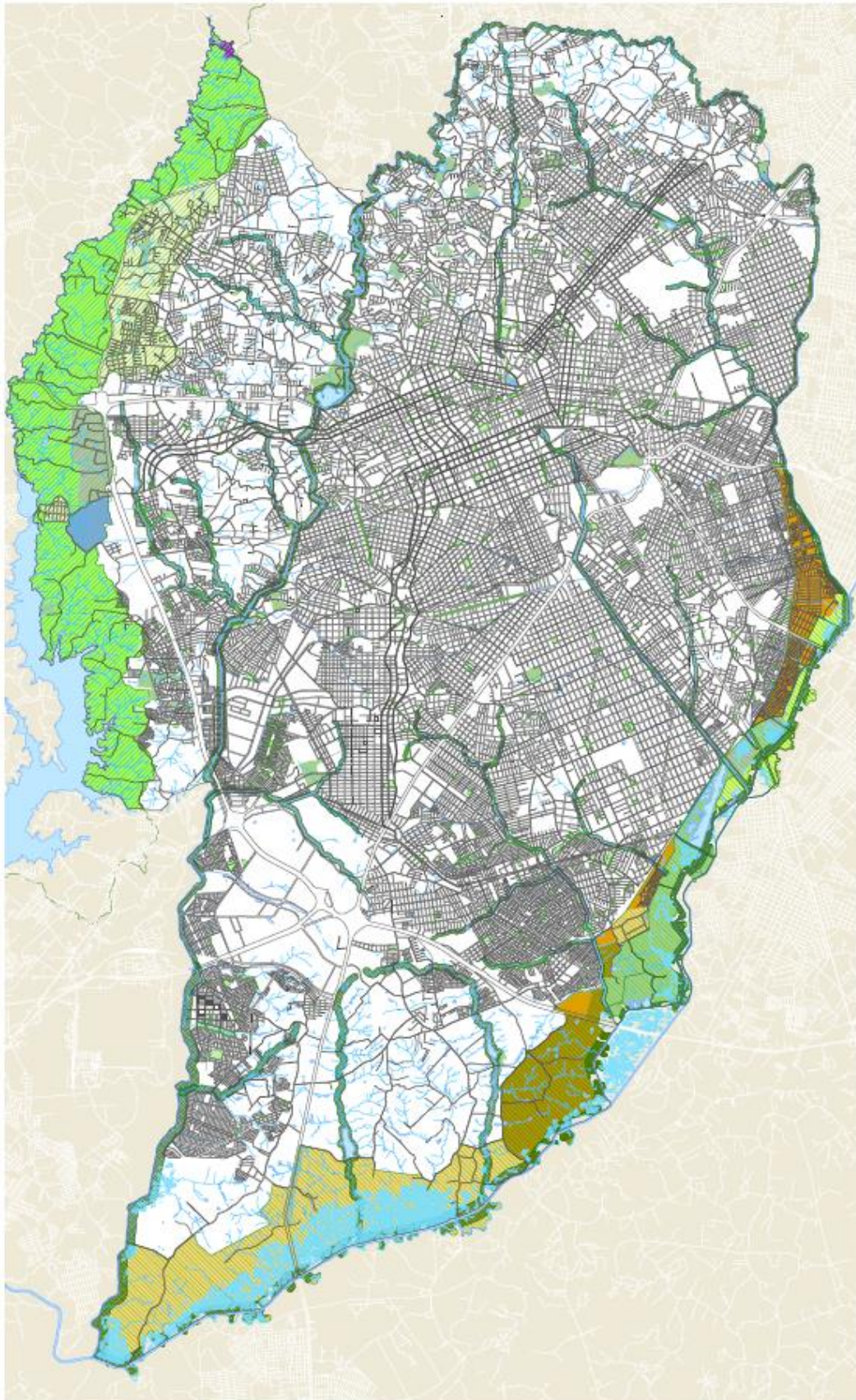
protection areas and urban arborisation within the city were evaluated. (ICLEA-BRASIL, 2016)

In relation to mitigation urban risk projects, the number of conservation areas is increasing with five new parks included in the "River-Conservation Park" project, the "Conservation Forests of Urban Biodiversity-BCBUs" and the decree of "Reserva del Bugio". All protected areas of the city have the capacity to act as sinks for greenhouse gases" (ICLEA-Brasil, 2016).

In 2014, the Municipality of Curitiba began to work on the revision and updating of the master plan, an administrative and legal procedure that has been done every 10 years. Through a process of public consultation with citizens, a document was finally published in the official newspaper on December 17, 2015, giving an account of the agreements and the new objectives of the Master Plan for the next decade. One of the interesting initiatives within the Strategic Plans was the proposal to elaborate a Plan of Mitigation and Adaptation to climate change, which is currently under development (PMC, 2018).

In 2014, the IPPUC prepared the *"Study of Environmental and Socioeconomic Vulnerability for the Municipality of Curitiba"*, a document that indicated, among other aspects, to consider the future impacts on the changes of the precipitation regime on the water courses, and the increase in the flows of the rivers in the rainiest months, which generate the flood phenomena, and the decrease in the less rainy periods (Figure 15).

Figure 15: APA Zones, hydrographical systems, parks and green areas



Source: (IPPUC, 2014).

Four possible scenarios were proposed, which foresee increases in the extension of the flood areas both for the recurrence period of 25 years and for the recurrence period of 50 years. The increases foreseen for the “Alto Iguazú Basin” range from 3% to 5%. It should be noted that although studies of climate change present a high level of uncertainty, they can help regional or municipal administrators on the vulnerabilities of their territories and can integrate these risks into their mitigation and adaptation to climate change actions (IPPUC, 2014).

With respect to the adaptation plans to climate change, the report on actions of adaptation to climate change carried out in 2016 by the municipality, indicated that:

“Cities that adopted the model of sustainable development and adequately conserve their natural areas have greater potential for adaptation, better resisting the impacts of extreme weather events, as well as having a greater potential for providing ecosystem services. For this reason, the conservation of natural ecosystems in urban and peri-urban environments is of utmost importance to reduce the vulnerability of cities to the impacts of climate change” (ICLEA-Brasil, 2016).

c.- Governance

Cities in development, like Curitiba in Brazil, recognized by their advances in transport and their sustainable urbanism, owe part of their success to their governance capability and its solid institutional arrangement. Its political commitment has been fundamental for Curitiba's success. A long-term vision in planning, like the integration of traffic and rational land use during more than 40 years of political continuity, with a succession of mayors that have continued the work of their predecessors over time and the institution a of a planning process as politically isolated as the IPPUC, has been crucial (Cervero, 2013).

Possessing an urban development plan does not necessarily ensure the success of the proposed aims if there is no political and technical will to implement it. In this respect we can find two singular aspects in relation to the type of governance that have made Curitiba's urban changes possible.

First, in the decade of the 1960 during the administration of Mayor Ivo Urzúa Pereira, the city resorted to the Company of Development of the Parana River, (CODEPAR) to obtain funds and to be able to call a national competition in 1964 for the new Director Plan for the city. At the same time a commission was created to guide the debates of the new Director Plan, the APPUC (Advice and Research in Urban Planning for Curitiba) whose role was to coordinate the professionals of the Municipality and the proposals of the new plan. That created the need to transform the commission of advisers into a public independent institution and a year later, in 1965, the Institute of Research and Urban Planning for Curitiba (IPPUC) was created, and it exists still today (Peña Flores & Escudero Peña, 2001).

The function accomplished during these 50 years by IPPUC has been fundamental in the urban and territorial development of Curitiba city, and its strengths have been its status as an independent agent, with its own finance and isolated from the caprices of daily politics and also being able to coordinate in a useful way urban development and the infrastructures of the city (Seto et al., 2014).

Another characteristic of this agency was the aptitude to overcome the bureaucracy of the city departments, with functional plans elaborated by the urban planners who managed to dominate the municipal government, due to the fact that Brazil's ruling military dictatorship was endorsing IPPUC, and civil servants could take decisions with relative autonomy (Irazabal Zurita & E, 2009).

The internal structure of the IPPUC was conceived with the purpose of including representatives of all branches of government in the Administrative Council, managing to establish functional links with other entities. In the creation of the Institute all its members were sharing the same political inclination and had taken part in the Plan creation. The IPPUC was also given authority over all the entities of government and from 1966 it has survived the political changes of the country and the transformations of the local process, and continues to be the most important entity of Curitiba's planning to date (Irazabal Zurita & E, 2009).

Secondly, durable political commitment has been another important element of Curitiba's success. The harmonization between transport and urban development was carried out over a period of more than 40 years, and was marked by a succession of

visionary mayors of related ideas that were based on the work of their predecessors (Seto et al., 2014).

According to Irazábal, C (2005), there is no better example of coincidental combined leadership role than that represented by Jaime Lerner, who personified the role of planner, mayor and governor in the decade of the 1960s. In fact, Jaime Lerner was the first chairman of IPPUC before being appointed by the military government as mayor of the city in 1971. Lerner was the first mayor to implement the Director Plan of 1965 as a direct political decision of his first administration.

The military regime trusted him to conduct a technocratic process of promotion of progress in the area, while they were controlling the population. Inside a military dictatorship, planners could pay less attention to the Municipal Council and to the popular movements, and make decisions themselves with relative autonomy, (with the significant exception of other powerful entities in the process the economic groups with interests) (Irazabal Zurita & E, 2009).

The success of the first innovations that Lerner and the IPPUC carried out in the transport system and in the use of land gave them the incentive to propose other innovations. Even the successive administrations by the opposition, in the 80s under the leadership of mayors Mauricio Fruet and Roberto Requião, had to follow the plan, which had already changed the structure of the city.

Since 1971, Lerner has been mayor of Curitiba three times, and twice the governor of the State of Paraná. During his periods as governor, he has had as mayors of Curitiba people of similar political ideas and similar philosophies of planning like Rafael Greca y Cassio Taniguchi (Irazabal Zurita & E, 2009).

In 1990 a series of legal arrangements between the State of Paraná and the City of Curitiba empowered URBS (Urban Development Authority of Curitiba) to plan and manage all the transportation modes within the Curitiba metropolitan area. Curitiba's approach is quite unique in Brazil as IPPUC and URBS play a key role to guarantee continuity in terms of transit and traffic solutions as well as urban planning. While URBS is responsible for planning and controlling transit in the metropolitan area and granting permits to bus transit operators, IPPUC consolidates urban development

plans, programmes and projects of different administrative units of Curitiba and its metropolitan area. Curitiba became Latin America's iconic city for urban planners in providing one of the rare cases where the realization of plans transcends political administrations (Lindau et al., 2010).

4.1.3. Urban acupuncture strategy and BRT project for mitigation action

During Jaime Lerner's first term as mayor, several small-scale urban projects began to be built, under the concept of "urban acupuncture". In his own works, he defined the concept:

"I always had the dream and hope that, with a needle-stick, it would be possible to cure diseases. The principle of recovering the energy of a sick or tired point by means of a simple touch that has to do with the revitalization of this point and the area around it. I believe that some "magic" of medicine can, or should, be applied to the cities, because many of these are sick, some almost in terminal state" (Lerner, 2003)

In 1972, it was possible to build the first stage of the "Rua das Flores" pedestrian promenade; the project consisted of transforming the street into a pedestrian promenade despite a lot of initial opposition from commercial business owners. For this reason, the strategy used by the mayor was to execute the project in 72 hours.

Finally it was a success, becoming the first pedestrian promenade of Curitiba and even in Brazil. Other areas of the city soon asked the mayor for permission to realize similar projects in their neighbourhood, especially because they saw that sales increased thanks to a better customer predisposition.

The project managed to extend through the street with the approval this time of the other merchants in the sector.

Using the same strategy of urban acupuncture, in a short time and with scarce resources, several urban facilities projects were built in the small lagoons in Curitiba. One of the first was La Opera de Arame, which took advantage of the space of an old quarry, and was built in 60 days:

"The intention was not to beat the record, but there are works that, for special reasons, have to be fast. In the case of the Opera de Arame, the reason was not to miss the opportunity to hold an International Theater Festival" (Lerner, 2003).

Another example of acupuncture strategy was the Free University of the Environment, which was built in two months. Another construction work was the Passaúna Park of 6.5 hectares, whose objective was to protect the water supply of the Paraná River and which was built in 28 days.

Everything was decided and built on the job. The common characteristic of these projects was their low budget, the speed with which they were built and the use of natural areas to incorporate them as urban parks for the use of citizens.

a.- BRT to Transport Oriented Development TOD

During the 60s and in a period characterized by the rapid urbanization of Brazil, many cities decided to invest resources in infrastructure encouraging private car ownership, thus causing the growth by extension of cities. In the opposite direction and taking advantage of the new Director Plan of 1966, and to avoid the cost of big scale projects, Curitiba began to encourage the physical planning of the city around linear axes that had an exclusive central express lane, emphasizing the integration of the urban systems, land use patterns and the system of public transport (Rabinovitch, 1992).

Curitiba took advantage of the opportunity to use federal funds during the decade of the 70s and to invest in bus corridors to give a response to the future city growth. Other cities in Brazil, such as São Paulo, Belo Horizonte, Recife, Porto Alegre and Rio de Janeiro, had the same opportunities but they did not do the same, they only made improvements to their public transport systems (Photograph 8). Three key periods in the history of the modern Curitiba can be identified; 1943-1970, characterized by the development of the vision of the future of the city through planning; 1972-1988, the execution of the plan that led to the consolidation of a system of bus traffic integrated in the whole city which was named Integrated Transit Network (RIT); and 1988 up to today, metropolitan expansion and improvements to the *integrated bus transit system* (Lindau et al., 2010).

Photograph 8: A typical tubo station in Curitiba



Source: CTS-Brazil.

The proposal of express rails was looking for the reduction of the concentration of jobs in the traditional centre of Curitiba returning the city centre to the pedestrians and allowing the preservation of the historical city centre. By means of a coherent programme of zoning and regulation of density the initiative sought to absorb the growth of the city along the structural north-south and east-west axes, promoting retail commerce and the services sector, limiting new developments in the central areas (Rabinovitch, 1992).

The linear system of transport has much to do with the modern structure of the city and is very similar to the clusters proposed by the architects of the Team X, which was applied to the city during the sixties. The project of the city planner Wilhelm consisted of the combination of the project for the monumental Avenue Paulista of Sao Paulo and of the proposals of clusters by Team X, like Toulouse-le-Mirail of Candilis, Josic and Woods (Montaner, 1999).

When the Bus Rapid Transit (BRT) began to be implemented at the end of the 1960s, an integrated infrastructure of urban transport was put to work based on a system of exclusive corridors following the principle of structural axes that helped to organize the whole urban area.

A typical structural axis includes two lateral blocks and three roads called triple system. The central avenue is dedicated to the traffic of buses (principal rail and turbo stations) and local traffic accessing buildings and car-parks. Parallel roads are dedicated to major speed traffic (including direct buses), and every street provides one-way traffic (towards the downtown and to the suburbs). The lateral blocks are divided in zones of mixed use and high-density developments. The lateral blocks most removed from the triple system are divided in zones to achieve a minor density. As a result, the urban development is linear along the structural axes.

The concept was shown to be successful over time in the achievement of linear transit-oriented development (TOD) with low cost and high impact. This system was created by the professionals of the IPPUC. Two of these corridors, the north-south and the east-west present the major population concentration and services diversity, commerce and public services, which are distinctive characteristics of a TOD.

“Curitiba is the cradle of the BRT concept with the introduction of bus lanes and feeder services in the 1970s and the Integrated Transit Network (RIT) in the 1980s, including prepayment, level access and large buses with multiple doors” (Lindau et al., 2010).

“In the 1970s, when Curitiba had only 400,000 inhabitants, plans for implementing a light rail transit (LRT) system were prepared. The idea was aborted due to LRT’s high capital costs. Instead, the IPPUC (Institute for Research and Urban Planning of Curitiba) conceived a trunk-and-feeder bus system operating along segregated median flow lanes as the central component of axial transit roads. This bus system was gradually upgraded until reaching the status of the first full BRT system in the world. In 1980, with the implementation of the east-west corridor, Curitiba consolidated the basis for the RIT. A single flat fare enabled a cross subsidy between short and long displacements by allowing users to interchange between trunk and feeding services at terminals and tube stations” (Lindau et al., 2010).

Today the city counts on an elaborate system of public transport (Photograph 9) that is the backbone for the functioning of the city, and that has been perfected over time. Curitiba relies on six exclusive corridors of BRT. The system was an integrated one until a few years ago with passengers paying a fare that allowed them to transfer between different lines of buses.

Curitiba is making efforts to reduce emissions caused by the urban transport system by means of the replacement of diesel buses by others that operate with biofuel. However, in 2010 Curitiba was compared with other 15 Latin American cities and with regards to the use of cars and motorcycles, the city had 0,50 vehicles per person, as opposed to the average of 0,30 (Siemens AG, 2010).

Photograph 9: Curitiba's tubo station in the historic centre



Source: author's photograph 2014.

“This internationally acclaimed and emulated rapid-transit bus system allows for users to pay one flat rate to travel throughout the city. Working throughout a

hierarchical system, whereby collector buses from outlying areas bring passengers to main city arteries, Curitiba's bus system is credited with saving approximately 27 million automobile trips and currently serves 1.3 million passengers a year approximately 85 per cent of Curitiba residents depend on the bus system as their main source of transportation.²³⁵ also, multiuse "Citizenship Streets" in the outskirts of the system provides outlying communities with a community centre with retail, sport facilities, transit connection, and government offices" (Irazábal, 2009).

b.- The new BRT; The green Line

Nowadays a new investment in BRT is being made. It is, the so-called *Green Line*, which consists of an exclusive corridor for buses 22 kilometres long, utilising the old federal highway BR 116, which was under-used due to other road investments realized in 1996.

In the year 2002, the Municipality through IPPUC proposed the Green Line project as the sixth BRT axis for the city, instead of leaving it only as a route for private vehicles. The Green Line initiated operations in May 2009 along an initial section of 9.4 kilometres. When finished the exclusive corridor will connect 23 neighbourhoods of the city in a section covering 22 km.

The idea is to apply the same criteria as the previous projects, through a triple system of routes, and through the management of land use, applying densification criteria to each route according to their importance. Besides, this new project incorporate urban renewal as a strategy for urban development using instruments such as land management on the basis of compensations, and also the construction of a 20,000 m² park (Gakenheimer, Rodríguez, & Vergel, 2011).

As well as improving the connectivity of the urban transport system of the city, the Green Line project also aims to reduce CO₂ emissions by incorporating a fleet of buses running on biofuel and the creation of green areas, the planting of 5,200 trees, building cycle routes and public spaces compatible with the urban dynamics foreseen for the zone.

Another area of intervention is the extension of the network for the treatment of waste water and rain water. In the Green Line, funds have been used to pay for linear parks along the corridor. The Green Line (Photograph 10) is a special case due to the low densities of the areas it goes through, the number of empty lots and the potential for renovation that the sector has. It also represents the futurist vision of using transport investments in transport accompanied by urban procedure and management tools to guide urban development (Rodríguez, 2013).

Photograph 10: Green line project



Source: (IPPUC, 2014).

On June 5th, 2014 Curitiba's Municipality started the project Curitiba Eco Electrical initiative aimed at the use of electric cars and minibuses for the Municipal fleet as part of the objectives for the programme of sustainable urban mobility. The vehicles run on electricity and have zero emissions of pollutants and noise. According to information of the Municipality, if 10% of its fleet were electrical vehicles, in one year some 96 tons of CO₂ would not be released into the atmosphere. At a later stage, they are thinking

of implementing a system in which the rent of cars and bicycles destined to the public services could be shared. The goal of the project is to integrate all services requiring urban mobility in an intelligent network (ICLEI & Brasil Fundacion Konrad Adenauer, 2014).

4.1.4. Parks and lagoons urban projects for Risk management

The system of parks, forests and lagoons is one of the more interesting mitigation actions that have been implemented in Curitiba in the last decades. Besides incorporating cultural facilities, cycle paths and recreation facilities for the population, some natural risks such as floods are controlled while at the same time absorbing CO₂ emissions.

In 1970, as part of their long-term planning, the municipality decided to acquire the adjacent areas to rivers and lagoons, with the idea of creating green reserves of parks and forests that accomplished the functions of environmental preservation, and recreation areas for sport and leisure.

Some parks are linear in form they lie beside some large rivers or at the bottom of a valley and function as natural barriers to prevent flooding and to protect rivers and creeks from degradation (for example their use as garbage deposits). The environmental legislation in force in the city defines five types of areas for protection: Environmental Protection Areas (APA); forests, areas of permanent preservation, areas of drainage, and areas of flood (Suzuki, Dastur, Moffat, Yabuki, & Maruyama, 2010).

Due to its geographical situation, Curitiba is provided with a dense hydrographic network being surrounded by diverse rivers that cross it, but it also suffers the impacts of intense rain that take place within specific locations, the most important of which is the basin of the River Iguazú.

In Curitiba the episodes of heavy rainfall that have caused major impact over certain vulnerable areas have been long studied and registered. The conclusion of such studies is that, when the volume of the rains exceeds the 60 mm/day, the impacts were mainly overflowing in areas close to them, rivers and creeks in turn causing

dangerous landslides. To analyse risk condition in Curitiba the occurrences of natural disasters, were investigated especially the floods between the year 1980 to 2007 (Zanella, 2006).

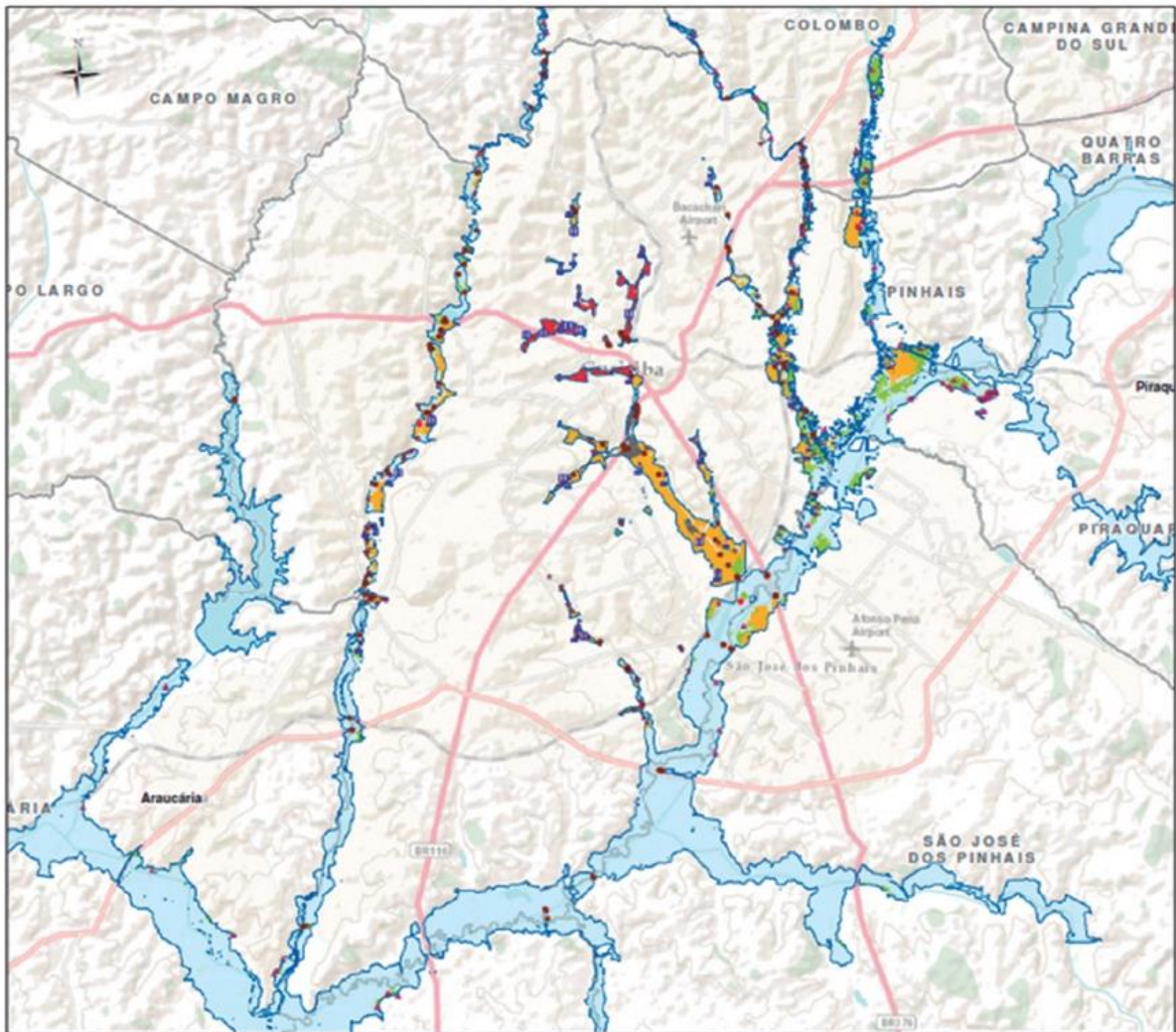
“Led by former three-time mayor of Curitiba, Jaime Lerner, the city planned energy efficient buildings that include an emphasis on site selection that respects green space. In order for the city to assure new projects will provide green/open space, developers are offered tax breaks. In 1970, there was less than 1 square meter of green space per person. Today, officials estimate there are 52 square meters for each person comprised of 28 parks and wooded areas. Flood waters are diverted into created lakes in parks solving the problem of dangerous flooding, while also protecting valley floors and riverbanks, acting as a deterrent to illegal occupation and providing aesthetic and recreational value to the people who use city parks”(Irazabal Zurita & E, 2009).

In order to control flood waters a natural system of drainages, has been created whose mission is to contain the rise of the rivers caused by the rains. The water is absorbed by the soil and mostly by the natural lakes inside the city. Thereby the water excess flows gradually in a natural form across this ecosystem avoiding floods in other sectors of the city. This system has turned out to be cheaper than building concrete channels (Suzuki et al., 2010).

In order to mitigate the effects of rainfall to the drainage networks in the central zones of the city, urban planning norms and procedure exist for big buildings, companies and malls that occupy 100% of their building area.

To guarantee the permeability of the soil, deposits of containment must be constructed in the subsoil which are destined to retain rain water, which is sent gradually to the drainage network, avoiding the formation of points of flood (Fukuda Hayakawa, 2010), see Figure 16.

Figure 16: Hydrological flood Curitiba



Source: (IPPUC, 2014)

It is necessary to emphasize that the city has increased its quantity of green areas per inhabitant augmenting from 1 m² per person in 1970 (ICLEI & Brasil Fundacion Konrad Adenauer, 2014) to 58 m² per person by 2010.

In the year 2010 the city had 101, 6 million m² of green areas (23% of the metropolis' territory) distributed in urban parks, forests, a botanical garden, reservoirs, conservation forests, private reservoirs, squares and gardens. The most important parks associated to mitigation risk urban projects are the following.

The Botanical Garden Park (Photograph 11), with an area of 178.000 m², houses the Botanical Museum with a permanent exhibition of specimens of the local flora and fauna. Its main construction is an iron and glass greenhouse, of 420 m². It is located near one of the lagoons that control the rise of the river.

Photograph 11: Lagoon Curitiba, Botanical garden



Source: Own 2014

Barigui Park (Photograph 12) was transformed into a park in 1972 by mayor Jaime Lerner. It has 1.4 million m². It is one of the major parks of the city. According to the municipality, is the most frequented park of Curitiba due to its proximity with the city centre and the diversity of its infrastructure.

Photograph 12: Barigui Park



Source: Prefeitura da Curitiba (SMMA, 2018).

Tingui Park was founded in 1994, it covers 380,000 m² and is located in the north side of the city. This park is a part of a project of linear park connecting Tingui Park , Guairaca Park (Photograph 13) and Barigui Park, all along River Barigui, as part of the system of urban parks.

It is important to stress that the natural lagoons (Photograph 14) formed by Barigui River are part of 20% of the total area of the park that has a flood control floods Tanguá Park (Photograph 15) was inaugurated in 1996. It has an extension of 235,000 m² and is located in an abandoned quarry. Before being a park, in this place there was a plant for recycling industrial waste. Tanguá Park is most distinctive feature is a tunnel excavated in the rock that joins two lagoons (SMMA, 2018).

São Lourenço Park was founded after a great flood in 1970 for the development of a project intended to control Belém River and to reutilize some industrial land. Today the old factory and the machinery have become the “Creativity Centre” a place for exhibitions, workshops and a library.

Photograph 13: Guairaca Park



Source: Prefeitura da Curitiba, (SMMA, 2018).

Photograph 14: Lagoon Free University of the Environment



Source: Own 2014

Public walk Park is Curitiba's oldest municipal green area, with near to 70,000 m². It was created by Alfredo D`Estragnolle Taunay and inaugurated in 1886. It is the most central park of the city and features a mix of cultural and sports facilities, and green areas with diverse native and exotic species. The *Public walk* was the first great work of rehabilitation of the city, Created to drain this area, transforming a wetland into a space of leisure, with lakes, bridges and islands in the middle of the green area (Leite & Henz, 2017).

Photograph 15: Tanguá Park



Source: Prefeitura da Curitiba, (SMMA, 2018).

For more photographs of Curitiba, the Appendix A can be consulted.

4.2. Medellín; introduction and methodology

In 2014, the World Urban Forum 7 was developed in the city of Medellín, Colombia organized by UN Habitat. A year earlier, the city had received an international recognition, the Urban Land Institute Award as the most innovative city in the world, and the Harvard Design Award 2013⁷ (Sotomayor, 2015).

The recent history of the most important urban transformations of Medellín, originated in 2004, with the arrival in Medellín of university professor Sergio Fajardo Valderrama, who governed during the period 2004-2007, and who was supported by a new social movement called *citizen commitment*, elaborated the bases towards urban transformations that we can appreciate today. This is the end of one of the darkest chapters of the city's history, known worldwide as one of the most violent and insecure cities. Thus, he began to create an ambitious Development Plan (Alcaldia de Medellín, 2008).

In 1993, the Urban Development Corporation (in Spanish Empresa de Desarrollo Urbano, EDU), was created, a decentralized entity of the Municipality of Medellín that is responsible for the development of urban projects defined as priorities in the Development Plan. During the mandate of Mayor Fajardo in 2004, the architect Alejandro Echeverri took over the direction of the EDU, giving it a new approach and creating a new specialized and interdisciplinary work team with exclusive dedication for the planning and execution of urban projects under the constant supervision and monitoring of the Private Secretariat of the Municipality. It is in this period that integral urban projects (PUIs) are created, intervening strategically in several peripheral sectors of the city with emblematic and innovative projects (Echeverri & Orsini, 2011).

The city is today a good example of participatory urban planning, social urbanism and environmental sustainability and has been recognized worldwide for its achievements in the areas of public transport (innovation with cable cars and escalators), urban rehabilitation, management in the use of land and public space, the generation of urban parks with cultural facilities (parks libraries), the creation of natural protection

⁷ Other important awards were the 2010 UN-Habitat Scroll of Honors for its participatory and poverty reduction programmes; the 2009 Gates Foundation Award for the educational impact of the Medellín Library Parks and the UN-Habitat Award for best practices in 2008 for improving living environments for the poor.

areas and a mitigation plan for the effects of climate change, the urban reforestation plan of 2007, the linear parks in the gorges, and the green belt in the hills (Reynolds et al., 2017).

One of the most innovative public transport and mitigation of climate change projects is the Metro cable. The first line (line K) was built in 2004 and connects one of the Metro stations that runs through the city from north to south with the ARVI natural park. It crosses a sector in the peripheral hills of the city called Comuna Nororiental or comuna 2, where the library park España was built in 2005 (Leibler & Brand, 2012).

During the period of Mayor Gaviria (2012-2015), a project called the greenbelt was proposed, which aims to create a natural mitigation system against potential natural disasters to achieve a more resilient city in the face of the inevitable effects of climate change, and on the other hand, to avoid growth by extension of the city, creating a public space for the leisure activities of the population.

The methodological proposal to address this second case, considers the following dimensions:

First, the historical process of the city is described, secondly, the beginning urban planning, thirdly the type of governance and the creation of the Urban Development Corporation (EDU), of the Municipality, and its importance for the achievements of the projects, Development Plans, citizen participation, and environmental sustainability objectives. Fourth, the mitigation projects that are being developed are shown. They are aimed at reducing CO₂ emissions to the atmosphere, through a public transport system, especially the creation of cable cars, integrated urban projects PUI and the concept of social urbanism.

Finally, some urban projects for risk mitigation and adaptation to climate change are shown and explained, such as the linear parks and the strategies that are being implemented in the first phase of the project called *the green belt*, which aims to stop urban growth by extension and mitigate the effects of natural disasters, landslides and floods, due to increased rainfall.

This chapter will conclude with the potentialities and limitations proposed by this case study and its possible implications and applications in urban contexts of large cities and with similar urban problems in the face of climate change.

4.2.1. The great Medellín future

The Metropolitan Area of Medellín is the second largest populated area in Colombia, composed of 10 municipalities located in the Aburra Valley. The Aburra Valley covers a total area of 1,152 square kilometers and its population in 2014 was 3,7 million, a figure that is expected to grow to 3,9 million inhabitants by 2020 (Martínez-Jaramillo, Arango-Aramburo, Álvarez-Uribe, & Jaramillo-Álvarez, 2017).

The city of Medellín was founded in the year 1674, with the name of *Nuestra Señora de la Candelaria de Medellín*. During the colonial period, the city began to expand its influence thanks to the trade of raw materials, food, minerals such as gold and precious stones, agriculture and textiles (La Manna, 2015)

In the 19th century, and after independence from Spain, Medellín became the capital of the department of Antioquia, and began to grow economically thanks to the export of gold and products from various industrial sectors.

At the end of the 19th century, the first planning proposals emerged for a mainly manufacturing and industrial city, and there was a concern for hygiene and circulation, issues typical of urban planning at that time. The Development Societies were created and in 1890 the first Plan for Medellín was formulated, but due to their short-term projections and their concerns about the rapid demographic growth of the city, the administrators left it obsolete in the first decades of the 20th century (Papantonakis-Vera & Rodríguez-Villamil Cardeillac, 2015).

In 1913, the communal council called for the drafting of a new Regulatory Plan, tending to regulate the development of the city (Photograph 16). The new plan proposed dividing the city into zones (industrial, commercial, residential) and an increase in road infrastructure, public spaces, parks and squares (La Manna, 2015).

However, during the 1920s, a private and informal urbanism prevailed, and from the public administration made efforts to implement a new *regulatory plan*. In 1934, the

Austrian urban planner Karl Brunner visited the city and offered his advisory services for the elaboration of a plan called "Great Medellín Future", but the public administration did not have the financial resources to sign a contract.

Despite this, Brunner left a series of recommendations regarding the growth of the city, new ordinances for the construction of new neighbourhoods and new housing, adequate zoning and urban roads (La Manna, 2015).

Photograph 16: Medellín's map



Source: (La Manna, 2015)

The unsatisfied demand for housing continued to exert great pressure and generated the formation of informal settlements on the edges of the city, which later consolidated as informal neighbourhoods (the so-called communes today) becoming one of the deepest social problems of the city, with alarming levels of social inequality closely related to physical infrastructure (Papantonakis-Vera & Rodríguez-Villamil Cardeillac, 2015).

The city grew and was more industrialized and these urban growths were spontaneous, there were no places to locate the population in constant growth, lack of infrastructure, services and green areas. The will to establish an urban order for the city arise through a planning instrument, the Municipality decided to work on a new regulatory plan for the city (Photograph 16), called Pilot Plan Medellín (La Manna, 2015).

4.2.2. From Pilot Plan to Social Urbanism

In 1948, the city hired architect José Luis Sert and his business partner Paul Wiener to draw up a plan for the growth of the urban area. In the international context of urban planning thought at that time, and according to Castrillón & Cardona (2014), the application of the principles of the Functional City in Medellín would be influenced by the contact that the town planners (Sert and Wiener) had with the Swiss architect Le Corbusier who had already been in Colombia. In the Plan for Medellín, they were based precisely on the ideas of physical and social planning discussed in the CIAM and modern movement⁸, exchanging growth for the creation of a new city (Photograph 17).

The implementation of the Athens Charter in the city was evidenced by the segregation of functions and the elimination of mixed-use areas. The articulating axes of the Plan proposed by Wiener and Sert were:

[...] “the city's general zoning proposal included areas for residential use, separated with green belts to isolate them from the industry; industrial areas to the south and commercial areas in the centre and around the main roads; large avenues parallel to the river as the basis of all urban mobility; recreational areas and parks; and the transfer of the administrative centre from the historic centre to the sector of Guayaquil with the proposal of a Civic Centre”⁹ (Castrillón Aldana & Cardona Osorio, 2014, p. 35).

⁸ The internationalization of the urban principles of the Modern Movement was in the hands of the extraordinary diffusion of the Athens Charter in 1943, eight years after its formulations in the CIAM of 1932. The fundamental problems of urbanism and modern architecture announced in that publication, were the four basic functions of the city: to inhabit, to recreate, to work and to circulate (Castrillón Aldana & Cardona Osorio, 2014).

⁹ Author translation

After a brief visit to the valley, and a few months of work in New York City, Sert finished the new Plan. The Pilot Plan, as it was called, in 1949 was in many ways ahead of its time and preceded for almost half a century the intellectual developments that would come to be known in the 1990s as Urbanism and landscape.

The main proposal of the Pilot Plan is not so much in the design of the streets and zoning of Medellín, but rather in the topographic characteristics of the city (Claghorn et al., 2015).

The most interesting innovation in the proposal of Sert and Wiener, were the plans that show in dark areas the ravines, recommending not to build in those places because of the dangerous terrain. It was recommended to establish a limit of urban growth, precisely in places with steep slopes where the mountain rises abruptly.

It is not sure whether the planners were aware of the risk of landslides on the slopes of the city, however the final message of their Master Plan was clear, the future growth of the city should avoid the occupation of the valleys. Despite the recommendations of Sert's plan, Medellín's growth over the next 50 years would take a very different direction (Claghorn et al., 2015).

The Pilot Plan was approved in 1950 by the Valuation and Urbanism Board of Medellín, and implemented in 1951 by the Mayor's Office with the name of The Regulatory Plan. In the following years, the Pilot Plan was modified and renamed the *Master Plan*. For this reason the original proposals of the Pilot Plan were never implemented due to the rejection of the common and standardized principles of how the modern city should be (Castrillón Aldana & Cardona Osorio, 2014).

Photograph 17: Pilot plan of Medellín



5 . Plan Piloto de Medellín del 194 .

Source: (La Manna, 2015).

The planning stage of Medellín during the decades of the 60s and 70s, was characterized by the abandonment of the modernist ideals of the city, which opened the doors to two new fields of action, according to Castrillón & Cardona (2014):

“The rupture (with the modern movement) would open two fields of action: the first would imply that the approach to the city, from its new definition, would be through specific architectural and urban tactics, which would supplant the urban plan of character generalist for what would be called urban project; the second would be with the new connotations of the term, in which the spatial intervention policies no longer prevailed since these were in the hands of the project, but they put their accent on the socioeconomic transformation of the city. With this last one, the development planning was born”

However, the process of planning and urban planning in Medellín, through the general plans of physical order and delimitation of the urban perimeter, maintained a

considerable boom, which enabled a new generation of plans to appear. Development plans were characterized by an emphasis on selective strategies. This definitely caused the decline of Pilot plans and Master plans (Castrillón Aldana & Cardona Osorio, 2014, p. 39).

During the decade of the 80s, in relation to urban planning, the national government proposed new development instruments for the city and metropolitan areas with comprehensive development plans, standards of densification, land use, expropriation measures, etc.

The Development Plan of Antioquia 1983-1986, was the first of its kind, after the Metropolitan Area was created in 1980, the Metropolitan Development Plan (PDM) was approved, in 1985 and served as the basis for the first Urban Development Plan of Medellín (PDUM) in 1987, which diagnosed new problems such as the deterioration of public space, the isolation of the urban road system from departmental systems, and on increased climate of insecurity, but also "positive trends": the resurgence of solidarity and the institutionalisation of citizen participation (Naranjo & Villa, 1997).

The Municipal Development Plan of 1987 (PDUM) proposed the decentralization of functions towards neighbourhoods of Medellín, creating a new territorial division for the city. The terms "zone" and "commune" acquired a new connotation. The commune is the largest division within the urban zone, the zones were delimited according to the urban perimeter and the grouping of these communes. Finally, the city was divided into 6 zones and 16 communes (Naranjo & Villa, 1997).

At the end of the 1990s, the "Medellín Strategic Plan to 2015" (PEM) was created, influenced by other Latin American cities that were also implementing their strategic plans. However, it could not be applied due to, among other things, the critical moment the city was experiencing at that time. In any case, the exercise of generating a diagnosis and rethinking the city for the next 15 years with a multitude of projects, laid the foundations for future urban development of the city and the generation of new leaderships that will be key figures in the future development of the city (Pérez Jaramillo et al., 2015).

Thanks to the application of Law 388 of 1997, in 1998 the Territorial Ordering Plan POT was approved, under the municipal government of Mayor Juan Gómez Martínez (1997 -1999). This Plan proposed to curb urban expansion and generate a model of inward growth and urban containment in the periphery, with emphasis on the redevelopment of the river corridor. Furthermore the urban renewal of central areas and of the metropolitan corridor along the Aburrá River, was a clearly on an environmental and urban improvement of the city.

According to Pérez-Jaramillo et al., the strategic vision of the POT was:

[...] “defines a model supported in the rural territory, and another of transition between rural and urban, to which a quality is assigned. The first has an environmental, ecological, agricultural and eco-tourist function, for which it must have the facilities and infrastructures required for its integral development and connection with the city. To the second, is assigned the function of protecting environmental and rural resources and containing the pressure of urban expansion. To the third, it determines several ideal issues such as the use of central areas, better endowed with infrastructure but degraded, for new developments; the integration of the Medellín River into the city and the qualification of the surrounding infrastructures; the incorporation of the hydrography and orographic system to the public space system; the hierarchy of multiple activity areas; the recovery of the traditional centre; the implementation of the integrated transportation system linked to the Metro lines; and, finally, the balanced mix of land uses”¹⁰ (Pérez Jaramillo et al., 2015, p. 5).

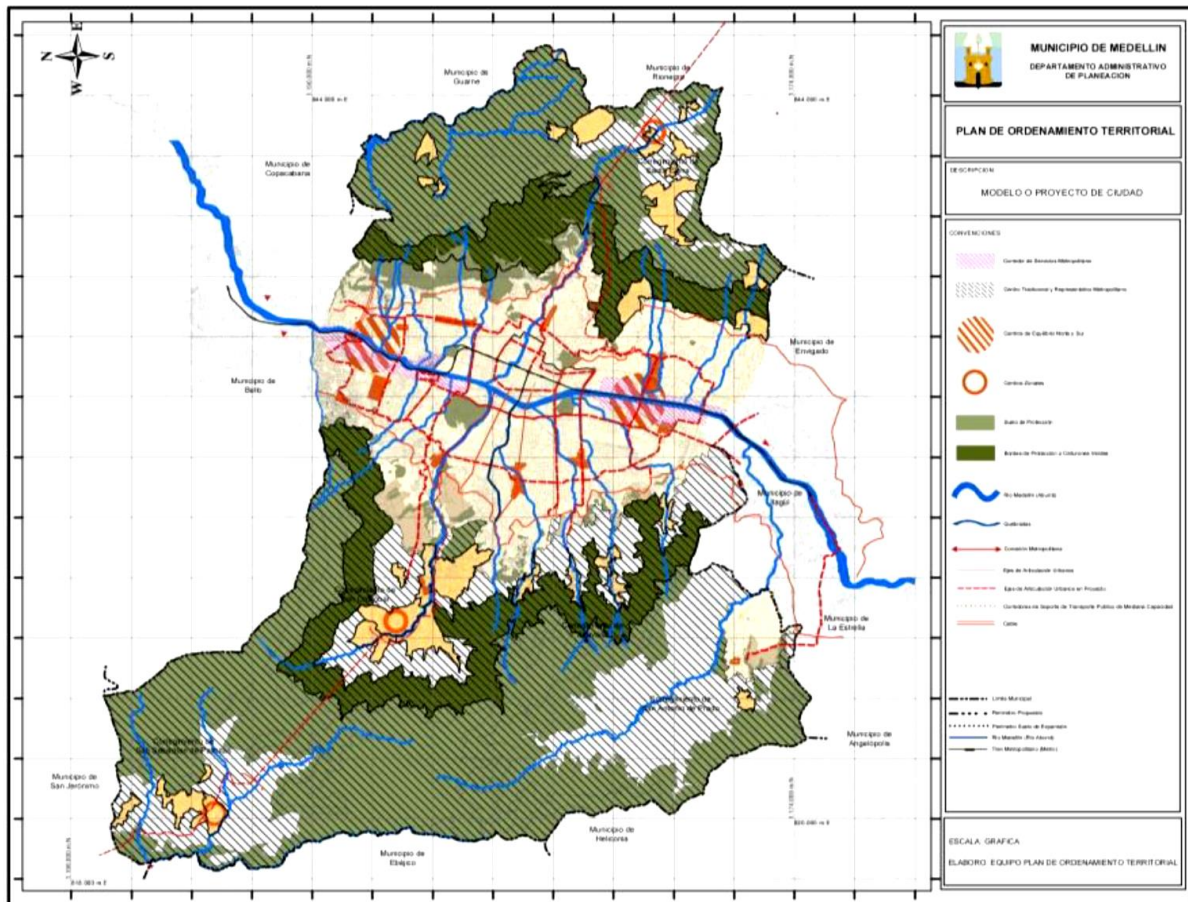
The POT¹¹ Territorial Ordering Plan of 1999 and the Sectorial Plans sought to maintain a certain control of the urban space and building, and to reinforce the relationship between the public and the private investors. Since the decade of the 80s, some sectors of the city had been developed by construction companies of the private

¹⁰ Author's translation

¹¹ The POT was subjected to a revision in 2006, some urban regulations were adjusted and modified

sector. It began to use a new concept (Photograph 18), The Strategic Planning¹² (Castrillón Aldana & Cardona Osorio, 2014).

Photograph 18: Strategic plan Medellín



Source: Departamento Administrativo de Planeación, Alcaldía de Medellín

At the beginning of the 21st century, the Municipal Development Plans were proposed for each period and aimed to guide the policies and actions of the municipal administration. The development plan for the period 2001-2003, under the mandate of Luis Pérez Gutiérrez, set itself the objective of starting the construction of the first Metrocable in Commune 1 and 2, to connect neighbourhoods with large social problems with a Metro station. This first line would be inaugurated in 2004.

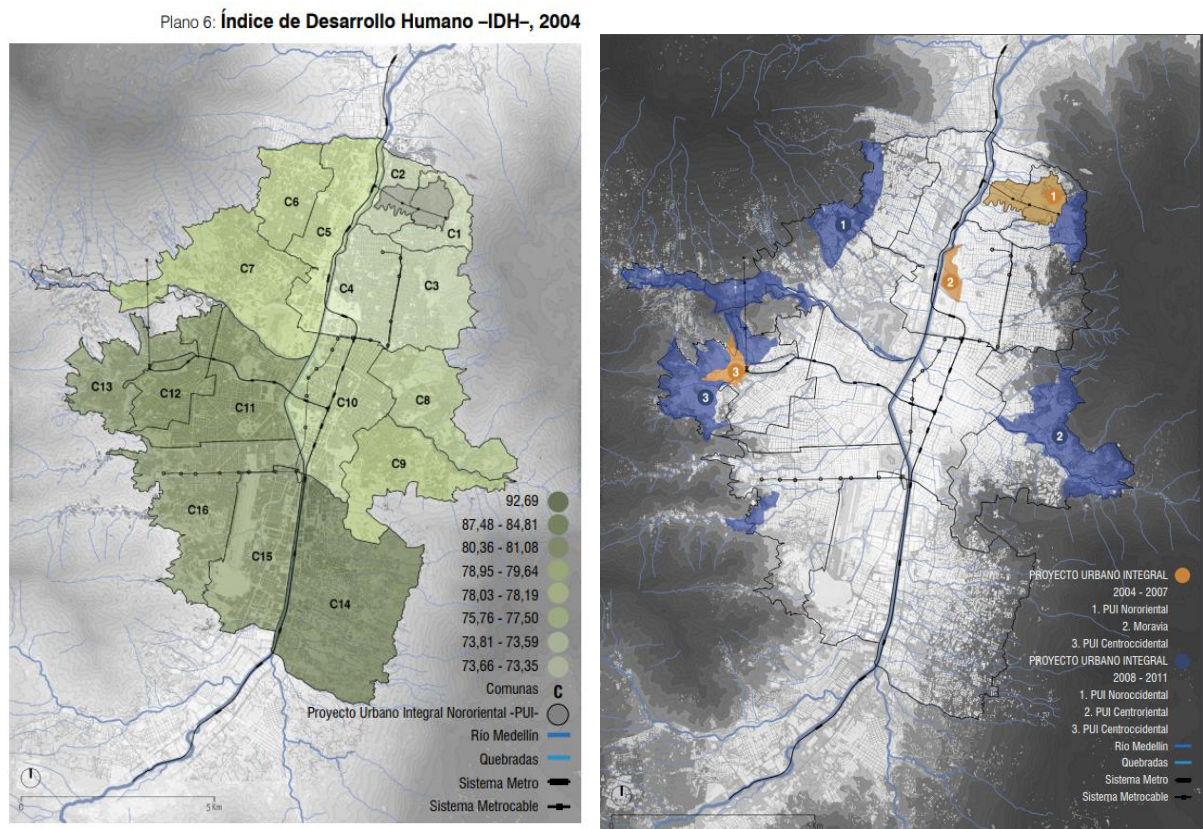
The next Municipality Development Plan was proposed by Mayor Sergio Fajardo Valderrama, during the period 2004-2007, which was based on a city model focused

¹² In the case of Medellín, Strategic Planning advocated for governments to eliminate certain urban regulations, to favour the operation of the market (...) as the progressive privatization of the public (Castrillón Aldana & Cardona Osorio, 2014).

on human beings and their well-being. This Plan identified two major problems of the city that mark the direction of the actions to be undertaken: on the one hand, the deep inequality and accumulated social debt, and on the other, the violence associated with drug trafficking that emerged from the decade of the 80s. In its configuration, two principal axes were proposed: the project "Medellín, the most educated", and social urbanism programmes (Papantonakis-Vera & Rodríguez-Villamil Cardeillac, 2015).

Fajardo's Development Plan was continued in the period 2008-2011 by Alonso Salazar, increasing the urban transformation both in relation to the built mass and in relation to an expansion of the areas of action (Papantonakis-Vera & Rodríguez-Villamil Cardeillac, 2015).

Figure 17: Human development index and Integral urban projects



Source: (De Medellín & Gaviria Correa, 2012)

During the period of Fajardo, Integral Urban Projects (PUI) were created (Figure 17), whose development began in 2004 with the implementation of several inter-administrative agreements signed between the Municipality of Medellín and the Urban Development Enterprise (EDU), identifying the territory of intervention in the Northeast

sector of the city, communes 1 and 2 within the framework of the Development Plan, a project called Medellín commitment of all citizens (EDU 2018).

In the next municipal administration, the implementation of the Integral Urban Project of the commune was defined. In 2008, the mayor Alonso Salazar Jaramillo enrolled in the Development Plan 2008-2011, “Medellín, solidarity and competitive”, the urban projects of the Central Eastern zone communes 8 and 9, North Western communes 5 and 6.

In the Development Plan of mayor Anibal Gaviria Correa, comprehensive urban projects were contemplated with the slogan: “Equity, priority of society and government”. Currently, the Municipal Development Plan for the period 2016-2019 is in force, with mayor Federico Gutiérrez Zuluaga under the expression “*Medellin counts on you*” (*Medellín cuenta con vos*) (EDU 2018).

Another important project was the “urban green spaces master plan for the metropolitan area of Aburrá valley MAAV”, implemented in 2007 for the Aburrá valley urban environmental authority.

[...] “in the Aburrá metropolitan area, it was estimated that urban trees save 6,712 megagrams of carbon dioxide emissions per year (Mg CO₂/yr) equivalent to the yearly emissions of 1,428 average petrol-engine cars, by avoiding the emissions of 5,090 MgCO₂/yr due to savings in electrical cooling and capturing 2,077 MgCO₂/yr” [...] (Dobbs, Eleuterio, Montoya, & Kendal D., 2018).

a) Governance

Following the theory of governance, the urban transformations of Medellín, can be divided into three stages (Bahl, 2012). The first, between 1984 and 1989 was characterized by an illicit hegemony, drug traffickers patronage and corruption and state military forces that relentlessly controlled the city, It resulted in a period of violence, a destabilization of formal government and a systematic loss of power of the urban poor, who populated the precarious hillsides in the mountains of the city.

In 1986, the popular election of mayors was approved, which, together with a decentralization statute, gave the municipalities greater administrative autonomy and made them protagonists of their own development.

A second phase began in which the municipality sought to intervene in the most vulnerable areas of the city and they began to carry out in the late 1980s until 1997 some progressive interventions, such as the Comprehensive Program of Improvements of Subnormal Neighbourhoods (PRIMED).

These were the first experiences in participatory design that had several objectives; the main general objective of the programme was the improvement of the quality of life of the population in the subnormal neighbourhoods of the city, unifying the city and improving the neighbourhood coexistence. One of the specific objectives was the mitigation of geological risk (PRIME, 1996).

A third period in the recent history of the most important urban transformations in Medellín originated in 2004, when university professor Sergio Fajardo Valderrama, who governed during the 2004-2007 period, arrived at the mayor's office of Medellín, he was supported by a new social movement called "citizen commitment", and he laid the foundations for moving towards the urban transformations that we can appreciate today (Alcaldia de Medellín, 2008). The strategy used by this mayor, incorporated the slogan, *Medellín the most educated* (Medellín la más educada), with urban renewal strategies in those peripheral areas of the city with the greatest social problems, for which the Human Development Index and the quality of life Index were used, and began with the most deficient communes according to that criterion.

Later this strategy would be known as *Social Urbanism*. To achieve this transformation, the best technical knowledge and the best quality in the designs were applied in the selected neighbourhoods (Echeverri & Orsini, 2011). An special interdisciplinary team began to work in initial policies and programmes, focused on transparency (fight against corruption), social participation, civic culture, education, security and public spaces (Hernandez-Garcia, 2013).

This is the end of one of the darkest chapters of the city's history, known worldwide as one of the most violent and unsafe cities, and work began with the inhabitants on an ambitious Development Plan (Alcaldía de Medellín, 2008).

The urban transformations of Medellín could not have been carried out without the help of a parallel entity for urban and project management. Already in 1982, the urban development company for the Aburrá Valley EDUVA had been created, which aimed, in principle, at the urban remodelling of a specific area of the city, the San Antonio sector.

But perhaps the most relevant and revealing concept of urban policy agency, was the amount of works and constructions that were made during its operation, especially in the decade of the 80s with the management of a new massive transport system that would structure the city from north to south, the new Metropolitan train began its construction in 1985 (Naranjo & Villa, 1997).

In 1993, the urban development corporation EDU was created, a decentralized entity of the Municipality of Medellín that is in charge of the development of urban projects defined as priorities in the urban development plan PDU. During the mandate of Mayor Fajardo in 2004, the architect Alejandro Echeverri assumed the direction of the EDU, giving a new approach to this entity, creating a new specialized and interdisciplinary work team dedicated exclusively to the planning and execution of urban projects under the constant supervision and monitoring of the Private Secretariat of the Municipality. It is in this period that integrated urban projects (PUI) are created as a way to act strategically in several peripheral sectors of the city with emblematic and innovative projects (Echeverri & Orsini, 2011).

The urban transformations of Medellín have been the result of a process of political maturation along with the commitment of civil society. The team of mayor Fajardo started the process, which had continuity with the successive municipal administrations, Alfonso Salazar 2008-2011 and Aníbal Gaviria 2012-2015. The continuity in power has defined an unprecedented scenario for the configuration of sustainable policies over time; perhaps the success achieved is due in part to this continuing political will (Hernandez-Garcia, 2013).

During the government of Aníbal Gaviria, the “municipal agreement 070” of 2013 was signed by means of which the guidelines of the environmental policies for the city were taken up again. The city was preparing to face global environmental changes, and it reacted with adaptation actions and mitigation projects by establishing an environmental observatory for the city, an environmental management system, and environmental council. In addition, in 2014 the POT was revised for the first time and it introduced the problem of climate change as a fundamental axis for the regulation of the city, with strategies such as ecological urbanism for adaptation to and mitigation of climate change, the metropolitan green belt, the management of areas with potential for carbon capture, an environmental system for risk management and climate change, and adaptation and mitigation strategies began to be discussed (J. J. Sepúlveda-Jaramillo, 2015, p. 35).

"Within the so-called" territorial bets ", the new Plan advocated an ecological urbanism as a strategy for adaptation and mitigation to climate change. The Plan will seek to establish and implement, in the first instance, adaptation measures that will include risk management and the consolidation of protected areas and, secondly, mitigation measures, with emphasis on the compact city model, the configuration of a network of urban green spaces, the consolidation of a subsystem of sustainable mobility and the implementation of alternative systems of energy saving in buildings and the promotion of food security programmes, improving the urban and rural habitat"¹³ (Alcaldia de Medellín, 2008).

4.2.3. Cable cars and integral urban project for mitigation action

a) Cable cars

One of the mitigation actions aimed at reducing greenhouse gas emissions has been the construction of an integrated mass public transport system. The metro that crosses the city and connects Medellín with all its metropolitan areas, works by means of electrical energy produced by a hydroelectric plant. In addition to the train system, the Metro increases its massive and clean transportation system with the incorporation of

¹³ Author's translation

a system of articulated buses of medium capacity running on natural gas, which function as feeders and whose emissions are considerably lower than those of vehicle powered of fossil fuels (J. J. Sepúlveda-Jaramillo, 2015, p. 40). Is calculated that between 2010 to 2016, total estimated reductions of tonnes of CO₂eq was 121,029. The annual average estimated was 17,290 (TCO₂ eq) (Olmos, 2015).

Complementing the Metro and its bus network, a cable car system has been built to reach the neighbourhoods in the hillside areas of the city (Photograph 19, 20). Both metro and cable cars are operated with electricity, and reduce the large volumes of CO₂ emissions of the city into the atmosphere.

Today a new means of transport is being incorporated to further mitigate CO₂ emissions, with the construction of an electric tram, which aims to cover other areas of the city combined with feeder buses and cable cars, and linked to the public bicycle system of the city (J. J. Sepúlveda-Jaramillo, 2015, p. 40).

Photograph 19: Cable cars, comuna 2, K line



Source: own, 2014.

Photograph 20: Overview Cable cars



Source: (Dávila, 2012).

The idea of introducing a semi-massive transport system such as the metro cable in the suburbs of the city, arose from a technical-economic need of the Medellín metro, inaugurated in 1995, whose main line runs through the city from north to south there were problems to build access roads to its stations due mainly to the difficult topography of some sectors of the city (Leibler & Brand, 2012).

We must remember that all those sector called communes, were the product of the illegal take-overs that occurred due to the massive immigration from the countryside to the city in the late 50's and 60's, partly due to the civil war that hit the country and on the other hand, the attraction of new urban job offers. Logically the local government and the population living in the city were not prepared for receiving such

an large number of immigrants. This phenomenon was called *urban colonization* (Naranjo & Villa, 1997).

Due to the need to generate a mechanism to attract new users to the metro and overcome physical barriers, Medellín's metro company (owned by the Municipality of Medellín and the Department of Antioquia), developed the technical studies of a proposed cable car, which It presented in the year 2001 with the name of Metro cable to the candidates for mayor, showing the technical and economic feasibility of connecting the popular and marginalized neighbourhoods with the rest of the city. This idea generated scepticism and was not taken very seriously. The only candidate who committed to the project was Luis Pérez Gutiérrez, who was the winner of the elections for the period 2001-2003 (Leibler & Brand, 2012).

The Metrocable was included in the 2001-2003 Medellín Development Plan entitled *Medellín Competitive* and its objective was to fight uncompromisingly against crime, poverty, unemployment and the shortage of public space. The first Metrocable line (K) was constructed in the northeast area of the city, connecting Metro line A with City Districts commune 1 (Popular) and 2 (Santa Cruz). Both sectors had a difficult, steeply sloping terrain that prevents the construction of railway lines, which gives good reason for the installation of an aerial cable car system to enable access to these areas.

Metrocable started operations in 2004 and four years later the second line (J) was added, which crosses City Districts 7 (Robledo) and 13 (San Javier), in the western central area. In addition Line L, the only one designed for tourist transport, was opened in 2010 and managed by Empresa de Transporte Masivo del Valle de Aburrá Limitada, the public of massive transport corporation of the Aburra Valley. There are currently two other cable lines under construction, H and M, which will cover the eastern central zone (Colomer Bea, 2016).

The Metrocable, which was initially thought of as a semi-massive public transport solution, became the spearhead for the next major urban transformation in the sector. This project opened the doors of the community and generated greater confidence, because people could move quickly to the city centre and the possibilities of accessing work, services and leisure were increased. On the other hand, the community felt that it was being incorporated into the rest of the city, social inclusion was just beginning.

Although the situation was complicated in the case of the popular peripheries of Medellín, since restoring the presence, control and legitimacy of the State required challenging powerful illegal organizations and partially suppressing an extensive underground economy, the Metrocable offered an alternative stable and secure mobility, not only for residents of the sector to the rest of the city, but also to facilitate access to the sector of state institutions and the formal branch of the local economy (Leibler & Brand, 2012).

Today the *Metrocables* are part of the Medellín Metro public transportation system, which consists of two elevated train lines and three overhead cable lines: the K line, the J line and the L line. Compared to other urban transport systems, cable systems can be built in a relatively short time and at comparatively low costs because they involve a limited number of a lots of land to be purchased. The cost of Line K of the Metro cable was around USD 24 million and that of Line J (inaugurated in 2008) cost USD 47 million. A disadvantage of the system is that technically you cannot exceed 3,000 trips per hour without incurring high additional costs (Dávila, 2012).

One of the advantages is that the cable car system uses electric power that, in the case of Medellín, comes from hydroelectric sources, to which is added that practically no local emissions generate. This is a comparative advantage at times when the cities are worrying about the excessive consumption of fossil fuels and the effects of CO₂ emissions on climate change (Dávila, 2012).

In this sense, the Metrocable system can be considered a mitigation project in the face of climate change, because it is contributing to reduce the emissions of CO₂ into the atmosphere; furthermore *the* “public of massive transport corporation of the Aburra Valley” (ETMVA), decided to apply one of the instruments created by the Kyoto Protocol, the Clean Development Mechanism (CDM), to the six metro cable lines. The ETMVA quote;

“Another important sustainable development impact of the project is that the project acts as a clean technology demonstration project with a potential replication in various cities of Colombia as well as in other Latin American cities. Only few aerial cable cars are used as mass transit systems including the Roosevelt Island Tramway in the USA. The project is thus not only novel for the

host country but also for the region and one of the only cable car based mass transit systems worldwide” (Empresa de Transporte Masivo del Valle de Aburra, 2018).

The idea was to incorporate this type of project in partnership with developed countries, which results in effective reductions of greenhouse gases emissions, GHG that bring benefits to both countries. The ETMVA quote:

“The positive environmental impacts due to reduced usage of buses and other fossil powered transport means are less emissions of particulate matter (PM₁₀), carbon monoxide (CO), hydrocarbons (HCs), sulphur dioxide (SO₂) and nitrogen oxides (NO_x) resulting in less ozone formulation also as a result of reduced NO_x and HC emissions. Local air pollution levels are high and especially curb side particulate emissions are considerable, due also to steep roads and outdated and badly maintained buses” (Empresa de Transporte Masivo del Valle de Aburra, 2018).

The CDM guarantees Parties of Annex B of the Kyoto Protocol that financed projects in developing countries, the concession of certified reductions of GHG emissions (in kilograms of CO_{2eq}) assimilated to the GHG reductions obtained through this project (Oliveira, 2015).

b) Integrals Urban Projects (PUI)

In 2004 the new mayor of Medellín, Sergio Fajardo Valderrama, a mathematician by profession and a university professor, was elected. Within his technical team, was the architect Alejandro Echeverri, who had been doing his doctorate in Barcelona and who assumed the position in the direction of the urban development corporation (Empresa de Desarrollo Urbano (EDU) of Medellín).

Echeverri was able to learn about the experience of urban renewal and, its methods and strategies in the peripheral areas of Barcelona. However, years before, academic projects and research were already being carried out between the University of

Medellín and the ETSAB of Barcelona¹⁴. Under his one year of direction the EDU, the integrals urban projects IUP defined as priority in the Municipality Development Plan were created.

According to Echeverri: “An Integral Urban Project is an instrument of planning and physical intervention in areas characterized by high rates of marginality, segregation, poverty and violence”. Taking into account these criteria, the northeastern *comunas* of Medellín were chosen for the implementation of the first pilot project, and according to the Mayor's Office, this sector of the city had the lowest levels of the quality of life index and the human development index. Another aspect to consider according to Echeverri (2011), was that the first Metrocable, which would connect the neighbourhoods with the Acevedo Metro station, was about to be inaugurated. The IUP took advantage of the location of the stations and the power stations, with the aim of complementing and expanding the impact generated by the Metrocable (Echeverri & Orsini, 2011).

One of the characteristics of these IUPs was the participation of the community in the process, and in the case of the northeastern *comunas*, mayor Fajardo applied three principles: each project had a management structure of exclusive dedication, the project combined the physical and social intervention, and the project is installed in the own commune to ensure the participation of the inhabitants of the community in all the decisions (Fajardo, 2007).

Echeverri explained “From the diagnostic and planning phase, to the execution phase, the community was invited to participate actively in the process, accompanying the technical teams, social workers and communicators in the performance of their tasks. Due to the breadth of the territory, neighbourhood scale committees were formed grouped in the areas of influence of each Metrocable station: Andalucía, Popular and Santo Domingo (Photograph 21).

¹⁴ [...] clear influence of the Catalan school and the postulates of the architect Manuel De Solà-Morales[...]

Photograph 21: Cable car station



Source: own 2014

These were not necessarily linked to the Community Action Boards (JAC) to prevent possible political influences and to increase the level of participation. The result was, for example, the creation of the imaginaries Workshops, where the community participated directly in the definition and design of the projects. The workshops had the merit of “promoting leadership, elevating the spirit of belonging and the level of commitment of the community towards the neighbourhood” (Echeverri & Orsini, 2011).

In this way, a consolidation process of the neighbourhood was implemented, which enabled to structure and plan the territory, not only to improve its accessibility, but also to connect the neighbourhoods, with public projects such as community facilities, parks, streets, promenades, escalators (Photograph 22) and pedestrian bridges. The urban project became a catalyst for inclusion and social development processes as an alternative to violence and indifference. The project Library Park San Javier, for example in the San Javier neighbourhood, commune 12 and 13 (Photograph 23), due to its strategic location and educational programmes, became the main reference of the community as well as the propellant of an approach to knowledge and education as an alternative to weapons (Echeverri & Orsini, 2011).

Photograph 22: Electrical escalators



Source: Own 2014

Photograph 23: Integral Urban project



Source: own 2014

Morro Moravia project (Photograph 24) is also an integral urban project located in Commune 2 of Medellín, with ecological features.

Photograph 24: Morro Moravia



Source: (Empresa de Transporte Masivo del Valle de Aburra, 2018)

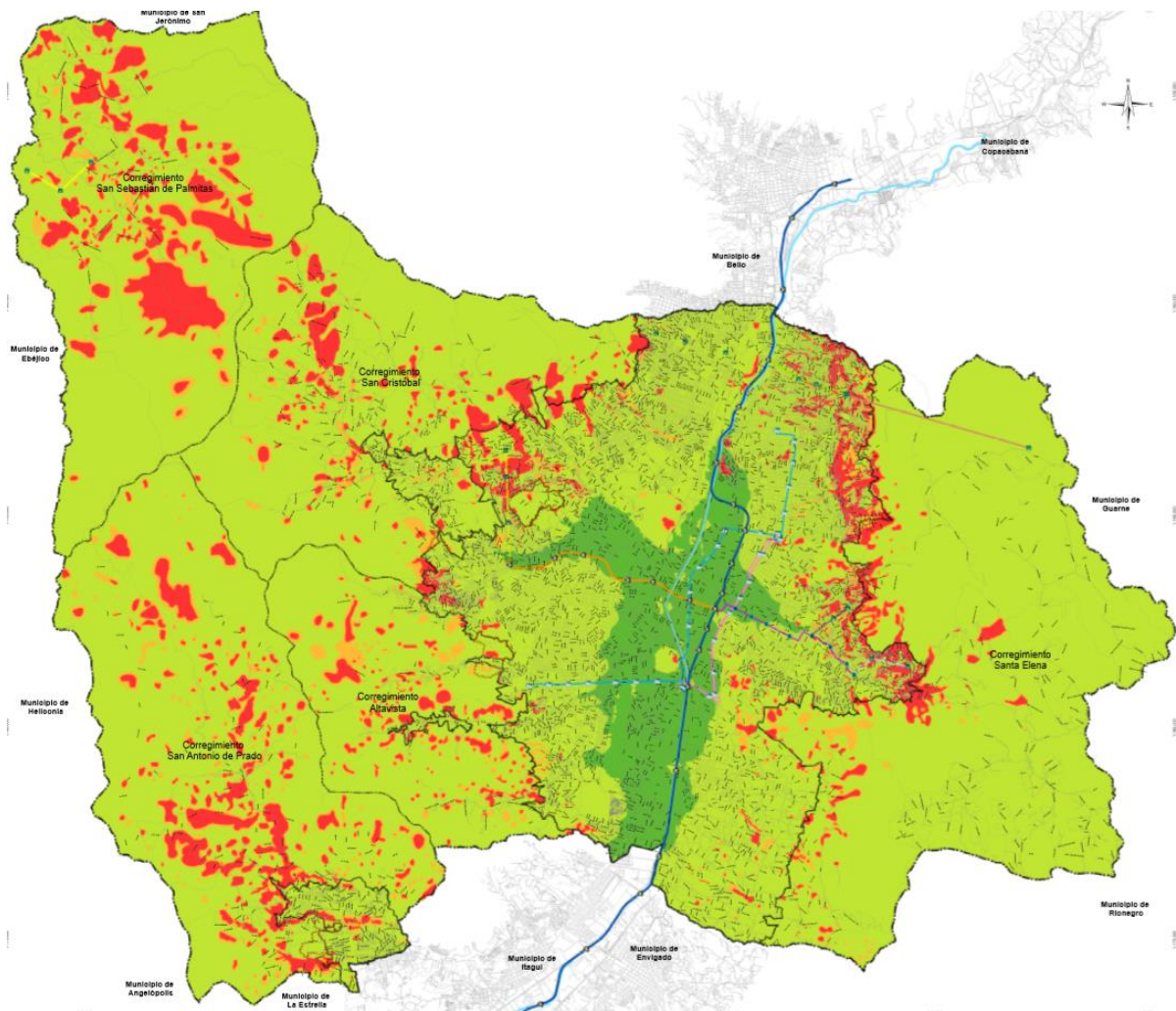
4.2.4. The green belt project for risk mitigation

The city of Medellín is preparing to face the effects of climate change. According to studies conducted by the IPCC 2010, in the metropolitan region of the Aburra Valley, there will be an increase in rainfall during this century.

For this reason, the Municipality signed the municipal agreement 070 of 2013 by means of which the guidelines of the environmental policies for the city are taken up again, and where the technical, methodological, legal and normative instruments for the environmental management of the city were established for Medellín (Figure 18).

With the update of the territorial ordering plan POT for 2014, the municipality incorporated new objectives to control climate change through mitigation and adaptation strategies. In 2015, during the mandate of Mayor Gaviria, two projects were proposed in this sense, the protection and increase of the protected areas the metropolitan greenbelt project.

Figure 18: Slides land risks metropolitan region of Medellin



Source: (De Medellín & Gaviria Correa, 2012)

The problem of climate change generated strategies such as ecological urbanism¹⁵ with the greenbelt project (Photograph 25), and began to talk about mitigation and adaptation strategies; in fact the POT's revision in the land use planning of 2014, incorporated explicitly adaptive strategies and mitigation to climate change (J. J. Sepúlveda-Jaramillo, 2015).

¹⁵ "Urbanismo ecológico como estrategia para la adaptación y mitigación al cambio climático. El Plan buscará establecer e implementar en primera instancia, medidas de adaptación que comprenderán la gestión del riesgo y la consolidación de las áreas protegidas y en segundo lugar, medidas de mitigación, con énfasis en el modelo de ciudad compacta, la configuración de una red de espacios verdes urbanos, la consolidación de un subsistema de movilidad sostenible y la implementación de sistemas alternativos de ahorro energético en las edificaciones y el impulso a programas de seguridad alimentaria, mejorando el hábitat urbano y rural" Ecological urbanism as a strategy for adaptation and mitigation to climate change", POT, 2014 agreements 2014, article 7.

Photograph 25: Circunvalar garden, first step



Source: © Gloria Carvajal P.

One of the strategies proposed as mitigation against climate change is the preservation and increase of the protected areas of Medellín that represent 44.39% of the total surface of the Municipality and in this sense, the Green Belt project promoted by the Mayor Gaviria, in the Development Plan "Medellín a home for life" 2012-2015, was proposed to regulate the use of the land, avoiding the expansive growth of the city towards the slopes of mountains and valleys, and also to preserve the natural areas.

In 2015, a team of landscape architects from the University of Kassel (Germany) and urbanists of Medellín, carried out a research and implementation plan to anticipate and mitigate risk in low-income settlements on Medellín's mountainous urban periphery (Photograph 26).

Photograph 26: Collage of forestation and ecological restoration of pilot project.

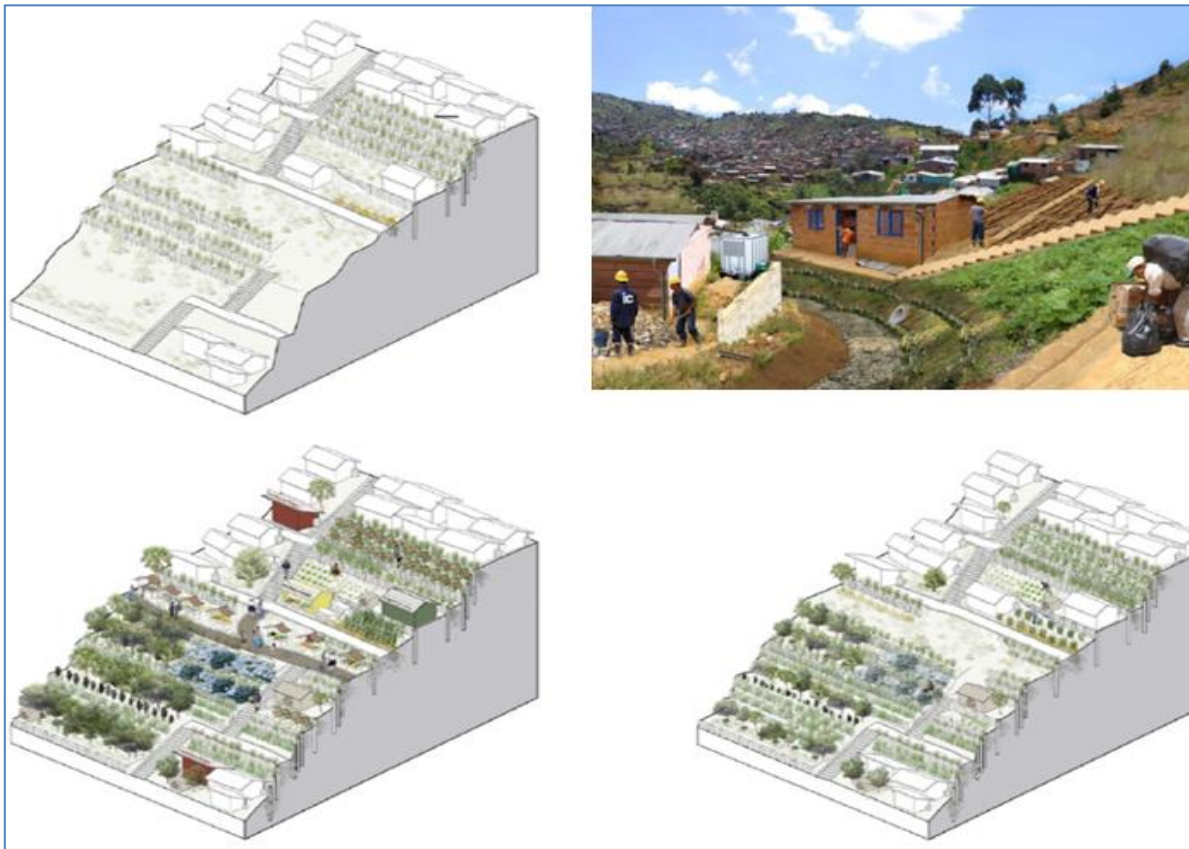


Source: (Claghorn et al., 2015) Echeverri Rastrepo et al (2013).

A first phase was elaborated examining the problem on the metropolitan scale and a second phase selected two specific neighbourhoods, where they proposed “five pilot projects to test strategies of risk alleviation (see Figure 19) through monitoring and early warning systems, drainage improvements, micro-farming, slope forestation, and through developing sites with supplied services.

Scholars have evidenced how deaths are increasing due to landslides produced by growing of torrential rains, due to climate change” (Claghorn & Werthmann, 2015).

Figure 19: Collage of forestation and ecological restoration of pilot project.



Source: Echeverri Rastrepo et al (2013).

The Metropolitan Green Belt project¹⁶ is a long-term integral planning strategy that aims to organize the territory in the meeting zone between the urban and the rural, through programmes and projects of the Mayor's Office of Medellín and the municipalities that make up the Aburrá Valley (Photograph 27).

Thus, the first pilot project to be carried out is called the *Circunvalar Garden of Medellín*, which began to be built jointly with the community through a pedagogical urbanism, that is, the inhabitants were taught to participate in the construction and social control for its maintenance (Aux, 2017).

¹⁶ [...] Implement the metropolitan greenbelt and build a metropolitan ecological structuring system as a natural base that provides ecosystem services and as an adaptive strategy to the climate change situation [...] POT, 2014, article 10 territorial strategies.

Photograph 27: Circunvalar garden, first step



Source: © Gloria Carvajal P.

According to the indications of the POT 2014 revision, public spaces will be implemented through the figure of eco parks for the mitigation of risk in border areas of high appropriation by the population through the metropolitan green belt, in order to protect the areas from landslides, and floods and contain urban sprawl. This project has been built in the sector of the commune 8 of the city of Medellín, with the consolidation of trails, bike paths, ecological parks, and some amenities (De Medellín & Gaviria Correa, 2012).

For more photographs of Medellín, the Appendix B can be consulted.

4.3. Findings comparison

According to the questions of the case study design illustrated at the beginning of this chapter, the main findings of both cases are presented simultaneously in Table 2 to understand commonalities and differences.

Table 2: Findings cases studies

What were the features of urban, strategic and territorial planning and how are risk issues developed in urban planning instruments?	
<p>Curitiba: In 1943 the <i>Agache Plan</i> incorporated sanitary guidelines, and dams were established to control events of natural risks associated with flooding of rivers due to torrential rains. In 1965 an urban plan was proposed with a model of growth through longitudinal axes interaction with social, economic and environmental dimensions.</p>	<p>Medellin: In 1948, a <i>Pilot Plan</i> was created with a special concern on city's growth and the potential dangers of landslides when hillsides are occupied by human settlements. In 1997 <i>the territorial ordering planning</i>, (POT) proposed to stop the city's growth by expansion and create a metropolitan ecological corridor incorporating the surrounding ring of parks into a green belt.</p>
Governance, what was the innovation and leadership role of mayors? What institutions were included in this process? How was the problem of climate change incorporated?	
<p>Curitiba: The figure of Mayor Jaime Lerner, architect, planner and governor, played a fundamental role in initiating and directing the urban renewal process. The Institute for Research and Urban Planning IPPUC was formally created in 1965; it had greater autonomy and incorporated more agility to the normal bureaucratic processes of planning and urban projects.</p>	<p>Medellin: Mayor Luis Pérez Gutiérrez implemented the first cable cars of Medellín which is considered as a mitigation urban project for climate change. The mayor Sergio Fajardo Valderrama implemented an environmental and ecological sanitation system within the watersheds improvement plan. The institution urban development company (EDU) is working together with the municipality.</p>
What were the characteristics of urban projects to be transformed into mitigation urban projects?	
<p>Curitiba: Public transportation known as BRT articulated buses in dedicated bus lanes,</p>	<p>Medellin: Urban risk mitigation projects included cable cars as a means of mass transportation that work with clean energy, and the</p>

<p>reforestation areas and urban parks were transformed in risk mitigation projects. The municipality proposed a climate change programme whose strategy was to "develop and apply a policy aimed at mitigating greenhouse gases in a local level".</p>	<p>recovery of streams and hydro graphic basins such as Morro Moravia with the linear parks plan. The territorial ordering planning (POT) was revised, incorporating ecological urbanism, mitigation and adaptation to climate change.</p>
<p>What were the mitigation urban projects for gas emissions and the natural risks?</p>	
<p>Curitiba: The mass public transport system implemented by Curitiba in all these years has become a global benchmark for efficiency, low CO₂ emissions and low implementation costs. With the development of the new green line transport and buses running on biodiesel, the transport system is helping to reduce gas emissions to the atmosphere. On the other hand, the implementation of an urban park, urban reforestation and protected areas around the city in the peripheral zones, are both urban mitigation projects in the face of climate change.</p>	<p>Medellin: Urban mobility projects such as the metro and cable cars were transformed into climate change mitigation projects because they work with clean energy, electricity produced by hydroelectric power plants, which do not emit CO₂ into the atmosphere. The previous municipal administration worked on the construction of a green belt for the city with several objectives: control the urban expansion towards the slopes of the hills, execute projects in the creeks that mitigated the natural risks, and be able to adapt to climate change.</p>
<p>How were mitigation urban projects contributing to combat climate change?</p>	
<p>Curitiba: The urban mitigation projects that have been developed in the city of Curitiba are contributing to combat climate change through the reduction of CO₂ emissions, through massive public transport projects. Furthermore urban reforestation projects and protection areas are helping to capture and store CO₂ gases.</p>	<p>Medellin: In the case of mass urban transport projects such as cable cars, today six lines are already running connecting the suburbs of the city with the metro. calculating the amount of CO₂ that this transport system avoids emitting and incorporating the project into the clean development mechanism CDM, this is definitely one of the instruments that help mitigate greenhouse gas emissions through green bonds.</p>
<p>How were mitigation urban projects connected with natural risks related to climate change adaptation projects?</p>	
<p>Curitiba: Cultural parks with small ponds and large urban parks with lakes and rivers are all</p>	<p>Medellin: Both projects called linear parks, which aim to control the ravines that reach the Aburrá</p>

<p>closely related to the concept of adaptation to climate change; in fact, the entire system of flood risk mitigation is being considered within an adaptation plan for a future scenario of increased rainfall for the next 60 to 100 years.</p>	<p>river, and the green ring project, which aims to control urban growth towards the slopes of the hills thus avoiding the risk of landslides are projects related to the new initiatives of adaptation to climate change, which was incorporated into the revision of the POT in 2014.</p>
<p>How were mitigation urban projects being integrated into urban planning?</p>	
<p>Curitiba: On December 17, 2015, an account was given of the agreements and the new objectives of the Master Plan for the next decade. One of the interesting initiatives was the proposal to elaborate a Plan of mitigation and adaptation to climate change.</p>	<p>Medellin: The revision of the POT in 2014 explicitly incorporates the actions of mitigation and adaptation to climate change based on the diagnosis made in 2010 and a projection of 2080 scenario of increasing rainfall and temperatures.</p>
<p>What are the main achievements and challenges?</p>	
<p>Curitiba: The city is internationally recognized as the first ecological and sustainable example in Latin America in different areas such as public transport through the BRT system and the urban management to buy the areas of wetlands and lagoons that had no commercial value and transform them into urban parks for the use of the inhabitants.</p> <p>Today it faces new challenges such as the uncontrolled increase of the automotive fleet, the social and spatial equity of the most precarious areas and the need to mitigate future risks of natural events and climate change in the most vulnerable areas.</p>	<p>Medellin: At the end of the 1990's Medellin was known as one of the most dangerous cities in Latin America. Nowadays the city is deploying praised innovation capacities in the arena of public policies and urban development, focused on social and environment aspects. The challenge is that the energy source of transportation should be completely converted to renewable energies.</p> <p>It is important to continue executing projects in the transversal green corridors, to mitigate the increases in rainfall and avoid landslides. A couple of projects are being developed under the current administration but it is not enough.</p>

Source: elaborated by the author.

Conclusions case studies

One of the first conclusions that binds both cases, is the indisputable role of the figure of the mayor. In the literature reviewed many authors argue that in order to implement actions against climate change, the figure of the mayor and his or her advisory team is key, and depends a lot on the type of governance.

In this regard we can say that in the case of Curitiba, a key element was without a doubt the undisputed leadership of Mayor Jaime Lerner who was able, through a vision of the city, to carry out in a short period of time the projects that triggered the great urban transformations of the city. Lerner was convinced that "every city can improve in only three years".

The most efficient plan of action that he used was the construction of strategic urban projects, through an operation called "urban acupuncture" with a very low budget to begin the transformation of the city. Jaime Lerner was mayor for three terms and governor for two, which facilitated the continuity of implemented policies. He even managed to convince succeeding, some politically opposed, to pursue implementing the urban city plan.

In the case of Medellin several mayors, not only one, had the vision and were convinced that it was possible to change the city and transform it into the most beautiful, friendly and safe environment for all its inhabitants. Some of the mayors were academics with a university background, some did not belong to any political party. The continuity in urban policies from 1999-2015, made the achievement of urban transformations possible.

The second aspect is the influence of urban planning. Both cases have a long and very interesting history of urban planning that started more and less one hundred years ago, and were influenced by modern urbanism that was fundamental for the future development of the cities.

The Curitiba case has a very interesting history of development of urban plans through its history in the last 100 years, influenced mainly by the urbanism of the modern movement of the 40s (as well as several Brazilian cities). The Agache Plan played a

fundamental role in proposing a vision of the city. The 1966 Master Plan and the following sectorial plans provided the basis for future urban transformations and served as a guide for local governments for the next 40 years.

In the Medellín case, it is important to remember that the city had an almost century-old history of elaboration of urban plans, therefore they had internalized thinking about the city with a vision of the future. The mayors relied on the municipal development plans and the territorial ordinance plan in force to succeed.

A third aspect to consider is the creation of an urban institute or urban enterprise. In the case of Curitiba the *Urban Planning and Research Institute (IPPUC)* was created and the Master Plan was implemented. The Institute was at the origin of the urban transformations, evidenced through the management and construction of strategic urban projects (urban acupuncture).

Through the IPPUC it was possible to build the first pedestrian promenade in the city in only three days. It is essential to note that having a department specialized in directing and managing the construction of projects for the city gives a great advantage over other municipal administrations that are unable to carry out projects of great impact for the city in a short time due to traditional bureaucracy and urgent work traps. The IPPUC shortens the times, works specifically on projects with highly qualified and multidisciplinary teams, and avoids, in Lerner's words, "that the inertia of the sellers of complexities, pettiness and politics make fundamental moments and works unfeasible"¹⁷ (Lerner, 2003).

The case of Medellín is very similar, in that the *urban development enterprise (EDU)*, played a fundamental role in achieving the city's urban transformations. It was created for a specific project and then played a very important role in carrying out urban transformations through strategic urban projects, in a short period of time. The integral urban projects (PUI) were implemented through the EDUs, which made it possible to start building projects in the most needy areas of the city. An example of this is the Morro Moravia ecological project, the first environmental sanitation project associated with the city's water basins.

¹⁷ Author's translation

A fourth aspect is the construction of a public transport system that allowed not only to give accessibility and solve a traffic problem, but also to cause a change in land use with urban renewal operations, regeneration in peripheral areas and reduction of CO₂ emissions to the atmosphere.

In the case of Curitiba, the *Curitiba Urban Planning and Research Institute* (IPUCC) had the capacity to innovate through the construction of the first bus rapid transport (BRT), as a cheaper alternative to the construction of an underground subway.

This project was not only a public transport project but also allowed the rehabilitation of urban areas, increasing urban standards through the use of land. Nowadays, the completion of the new Green Line with the incorporation of buses running on biodiesel, will become a new contribution for the reduction of greenhouse gases.

In the case of Medellin, the key element was the courage and risk involved in gambling on innovative projects, such as the case of the first cable-car as mass public transport. This project and the following ones were built during this period and gave accessibility and connectivity to peripheral sectors of the city. They were used as a spearhead for the subsequent urban rehabilitation operations of the newly accessible neighbourhoods. Both cities were pioneers in the creation and implementation of innovative mass transit systems that are now being replicated in various parts of the world.

All of these initiatives have been transformed over time into a new generation of urban projects that can be called "urban projects to mitigate climate change".

Examples of this type of project, in the Curitiba case, are the new urban mobility projects, such as the "Green Line", conceived in more ecological buses that run on biogas. This project is incorporating a strategy of urban renewal just like its predecessors BRT projects did. In this case, the challenge is to introduce mitigation actions to climate change such as green roofs and rainwater collection for irrigation, and incorporate new green areas into new projects. However, the pending challenge is the generation of compensation policies for the new construction of a percentage of social housing in the new areas to be urbanized around the transport lines to avoid social segregation.

In the case of Medellin, a new generation of urban projects was created which have an important role in the understanding of how to link different scales in urban analysis in terms of climate change, and how to go beyond the traditional macro level analysis. Examples of this new type of project are the mobility projects such as cable-cars, escalators, the transportation system of the new tram, the city metro, and urban reforestation. They are emitting less CO₂ into the atmosphere mainly because they are supplied with hydroelectric energy.

A fifth aspect is that another group of urban projects to mitigate natural risks has emerged. In the Curitiba case 27 urban parks are located in the lagoons and forests that surround and cross the city, conceived at the beginning as urban projects to avoid of the rivers overflowing in the rainy seasons. One of the characteristics of these projects are the introducing urban cultural projects, such as the F.M. Garfunkel Botanical Garden (1991), Wire Opera House (1992) located in the forest of the “das pedreiras”, and the Free University of the Environment (1992), among others, is that they took advantage of the small lakes that play a role in controlling river levels in times of torrential rains, transforming them into urban parks, increasing the number of square meters of green areas per inhabitant. Today these projects are laying the groundwork for the next generation of interventions, those of adaptation to climate change.

In the case of Medellin, another group of mitigation projects for risks that also need to be mentioned are the Morro Moravia projects (Olguín Báez, 2016) the rehabilitation project of the Juan Bobo neighbourhood (Echeverri & Orsini, 2011) and its creek, the urban arborisation and protected areas, the project of the banks of the river Aburra, the green corridors associated with the transversal ravines and one of the latest projects in its initial stages of construction, the green belt; with circumvent garden (J. Sepúlveda-Jaramillo, 2015). All these projects were conceived as mitigation urban projects to natural risks, to avoid soil runoff due to excessive rainfall and the river's overflowing.

Finally, in Curitiba's case, to achieve a more resilient city it is necessary to continue with the programmes and initiatives that are being developed by local governments and the metropolitan region for climate change adaptation projects, based on the predictions and possible scenarios of water increases due to torrential rains and future floods that could put at risk vulnerable urban areas. Today they are laying the

groundwork for the next generation of projects, those of adaptation to climate change. These projects can also be associated to the new category of “urban projects for mitigation to climate change”.

On another hand, in the case of Medellin, new laws have been generated on a national level, plans and programmes that indicate the development of projects to adapt a city to climate change to achieve a greater resilience to its effects.

Various challenges are pending for the development of mitigation projects. In effect, the municipality must maintain the continuity of urban development policies, especially the projects that are in their initial phases of implementation in the field of mitigation of natural risks and climate change such as the "greenbelt" project or the initiatives that are being studied in urbanism laboratories of universities. In this way, Medellin can avoid future local governments changing or stopping the programmes and the long-term plans.

Chapter 5: Discussion

The aim of this chapter is to present the discussion of the findings of both cases, Curitiba and Medellin. The results obtained from this research may be useful for other cities to introduce mitigation actions to climate change in their urban projects and may influence different areas of urban development, such as:

Leadership and governance: Cases teach us that similar results can be achieved through two different types of governance. The study and the researchers affirm that the strong leadership of a mayor and the methods that come close to an entrepreneurial model with citizen participation from top to bottom and vice versa, can achieve better results when implementing policies and mitigation actions in relation to climate change.

Urban planners: according to the research and the various authors who have written on this subject, urban planning is fundamental to be able to act in the face of climate change. City planners must update their knowledge and tools to address these new challenges. Climate change planning is a new concept that must be incorporated into the agendas of urban planners.

Urban policies: The case studies show the need to create the figure of the urban institute, precisely to involve planners, mayors, and politicians in the urban policies and to generate the link with the community and public and private companies. The case studies show that this consultancy model in planning and execution of urban projects is directing all its efforts toward the achievement of plans and projects to mitigate climate change. The next step is adaptation to natural risks.

Educational institutions: Future urban developments must incorporate both universities and technical and professional institutes. The faculty of local architecture and the institutes of urban studies are good examples of collaboration. The creation of alliances between local government and higher educational institutions is crucial for collaboration consultancy and constitutes an important synergy of knowledge and use of local human resources.

Mitigation urban projects: The research has the virtue of incorporating a new concept of urban project related to the city and climate change. This urban project belongs to a fourth generation of projects on a city scale that are incorporating mitigation actions to climate change, which on the one hand prevent and capture CO₂ emissions into the atmosphere, for example, public transport and urban regeneration projects, and on the other hand, projects to mitigate the risk of natural events, for example, parks, streams, riverbanks, containment lagoons, etc.

These mitigation urban projects have many functions, for instance:

- an executing function: on the one hand it is able to reduce the CO₂ emissions to the atmosphere and on the other hand it can mitigate the risks of catastrophic natural or anthropic events.
- it has a function that triggers other intersectoral projects that help to mitigate risk areas, not necessarily of direct impact on CO₂ reduction.
- It has an economic function, for the alternative cost and the economic development surrounding the projects.
- The mitigation urban project has an operational function transforming the guidelines of the urban plan of the city through concrete actions of urban rehabilitation strategies in the most vulnerable areas. It has the ability to translate the macro scale of city to a smaller scale with a higher level of precision and detail.
- it has a function representative of the geographical and historical context of each city, and of social aspects such as the type of citizenship participation and how universities have been integrated through architecture schools in the discussion and proposals for the urban development of the city.
- The mitigation urban project has a strengthening function of the governance of a city, its dynamic strategies legitimate the local governments to quickly and efficiently carry out urban transformations in sensitive areas, such as social, economic and environmental fields.

Not all the conclusions of both cases are replicable. The former mayor of Medellín said in an interview that he cannot copy the management model of his city and apply it directly to others. You must learn from experience to be able to generate your own tools that have the same purposes. In this case and in Curitiba, urban projects were created to improve the quality of life of the inhabitants, and they were unintentionally and inevitably transformed into emblematic, sustainable projects with direct actions to mitigate climate change.

According to current theories, in the last 10 years research is focusing on the subjects of adaptation to climate change and urban resilience. This research insists on the need to retain urban projects as a powerful tool that can mitigate the effects of climate change, influencing CO₂ emissions and mitigating natural risks.

In the same way mitigation and adaptation actions cannot advance separately. In fact, part of the mitigation actions is the basis for climate adaptation actions. This is demonstrated in the Curitiba urban park projects that incorporate a park design project with facilities inside a risk mitigation project, transforming it into public spaces for the use of its inhabitants.

A future investigation could address cities where similar projects are being executed, so for example urban projects that incorporate both mitigation variables CO₂ emissions and natural risk to become an integral urban project to mitigate climate change.

Secondary data were used to analyse cases and they were prepared by several institutions that have different purposes and effects on stakeholders. The answers of the research question could be reviewed and updated through primary data from focus group, interviews or surveys to confirm and reinforce relevant aspects covered by the secondary data.

The research has the limitation of considering only all built and completed urban projects and not those in a planning phase that could enrich the analysis and accentuate the trends or confirm some of the findings.

The urban projects described in each case have high potentialities to obtain carbon bonus funding but were not developed specifically with the aim of receiving funding. It

may be interesting to assess how the cities could move on to this further step and take better advantage of possible funding.

The political context and the centrality of public policies are relevant elements that explain local decisions in terms of their scope, funding and speed of construction. The research has found that different strategies and political contexts can encourage the implementation of urban projects with climate change impact. However, centralism and decentralization should be elements of further studies to better understand whether they may be limiting, and to comprehend their influence on the political orientation of liberal or social markets.

The success of the cases studied which have all received international awards, can be analysed in terms of how this positive feedback is at the origin of motivation of teamwork and how dependent or independent they are. Another interesting theme is to understand the cycle of cities success and its impact on the outcomes of urban projects.

Final conclusions

This research studies the relationship between cities and climate change, and specifically how urban projects can help cities implement their mitigation actions to combat climate change.

Through the development of the different chapters, it has been established in the first place that cities are largely responsible for the increase of GHG emissions to the atmosphere, on issue that has been widely discussed and demonstrated by numerous studies both in the scientific academic area as well as by institutional organizations worldwide.

In this sense, cities are two sides of the same coin. On the one hand they are responsible for the increase in GHG emissions due to accelerated urban growth and expansion, energy consumption, emissions from landfills, burning of fossil fuels to generate electricity and for public and private transport. On the other hand however they are vulnerable to climate change, mainly torrential rains, which cause landslides, and flooding in cities near lakes or rivers, or hurricanes in coastal areas.

In the Latin American context, cities will play an important role during the 21st century as it is estimated that they will reach almost 80% of the total population, and they will have to continue confronting the historical social, environmental and economic problems, but they must also generate strategies to fight against global warming. Actions against climate change are of mitigation and adaptation

Several studies have expressed the need to incorporate both strategies in the climate plans of cities. Mitigation alone is no longer enough in the face of the imminent increase in global temperatures during this century, which in the best case should not exceed 1.5 degrees Celsius.

Furthermore merely developing adaptation strategies without minimizing emissions, will not be effective and costs will be incremental over time and unsustainable especially for cities in developing countries.

It can be stated that in order to achieve cities that are more resilient to climate change, cities must develop urban projects that include mitigation actions in their two typologies

in addition to climate adaptation actions. In fact, there is a very strong relationship between mitigation projects and reduction risk projects and evolved into an adaptation project.

Consequently, the relationship between cities and climate change is evident, because the world population will continue to grow according to the global trend and especially in Latin America people will live in cities with more than 10 million inhabitants. In addition, the consumption of energy, food and transport, waste disposal, housing and infrastructure will increase proportionally.

Therefore, an urban project to mitigate climate change, in the context of Latin American cities, is being carried out through two typologies. The first is the use of public transport and the second is the mitigation of risks on a local level of natural events.

The first public surface transport system that was built in an alternative way was in Curitiba in the 70s and was called BRT. It was thought as an alternative means of transport to the metro, much faster to implement and cheaper.

This transportation system is being implemented in several cities in Latin America, the United States and in some cities in China. In the case of Curitiba and Bogotá, for example, transport projects incorporated strategies for urban renewal and / or public space design, and this type of strategy is known as *TOD or transport-oriented development*.

The second typology that has been used in some cities in Latin America is the mitigation of natural risks through the so-called green and / or blue infrastructures, which in this case in particular means the creation of reforestation projects in peripheral and urban areas, the construction of urban parks in buffer zones near lakes or river fronts and projects in areas vulnerable to landslides caused by rainfall or streams that have been occupied by informal housing.

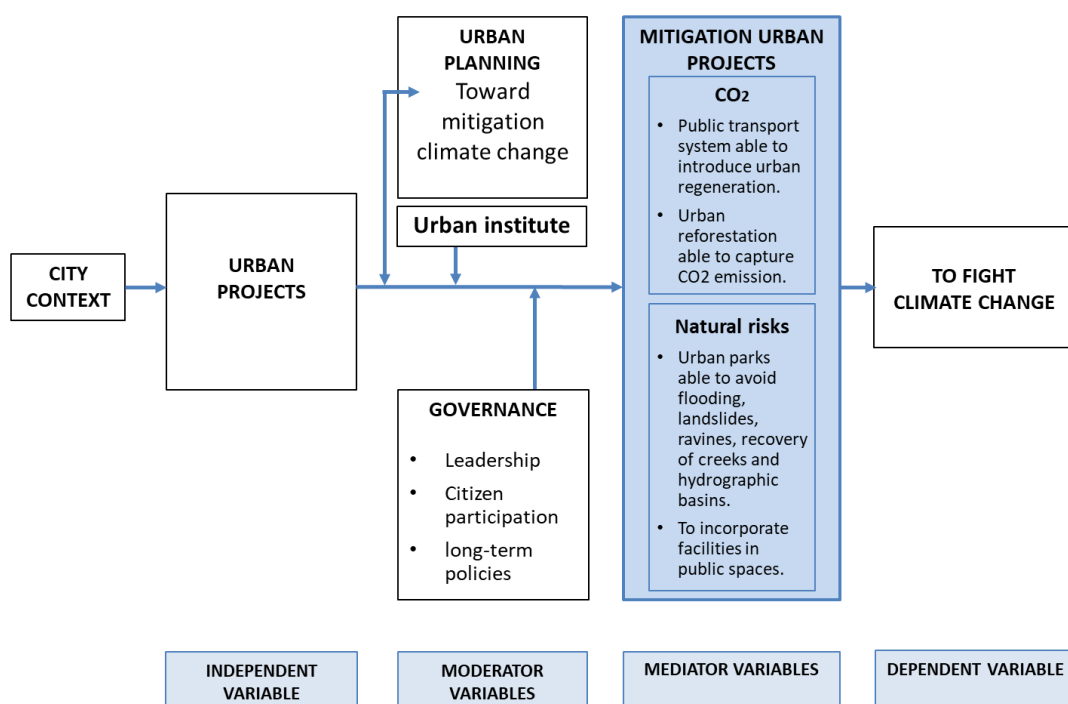
For both strategies, research indicates two fundamental aspects that should be considered. In the first place, urban planning with all its regulations and procedures continues to play a fundamental role, above all in the management of land use and

zoning, encouraging urban renewal and thinking about the future impacts of climate change during this century.

A second aspect to consider is urban governance. In this regard there are several examples worldwide and in Latin America where the role of mayors with strong leadership is essential to implement long-term policies that persist in time, supported by the figure of urban institutes that articulate the public-private relationship, manage and build the plans and projects and establish links with the citizens through top down and bottom-up participation in the whole process.

To answer the research question “**How can mitigation urban projects contribute to reduce the climate change in Latin American cities?**” using the two cases of analysis, it is possible to reconfigure the initial framework presented at the end of the literature review chapter. Variables of the framework were depicted for each case study and are organized in terms of relationships, establishing that the independent variable is urban project that produces as causing variable, an effect in the dependent variable, climate change (see Figure 20).

Figure 20: Connecting urban project with climate change



Source: elaborated by the author.

The analysis of cases illustrates that there is not a linear relationship between independent and dependent variables in this causation process. Variables already detected in the literature review step and new ones resulting from the case studies are playing different roles. In conclusion, the urban project independent variable is combined with two groups of variables that are also responsible for fighting climate change. The first are mediator variables and the second are moderator variables.

Mediator variables are between the cause and the effect in this causal process or chain; they constitute mechanisms that are influencing the outcome. In the cases studied, as a consequence of the implementation of urban projects there are CO₂ reductions, and mitigation risk facilities and infrastructure have been built, that lead to a change in the dependent variable, climate change.

The second group of variables are moderator variables associated with the broad concept of governance variables. Governance includes leadership and citizen participation, as recognized originally by scholars in literature, and a third component which emerged from the case study are urban institutes that are supporting the local government in various areas, from planning to execution of projects.

These three moderator variables are affecting the strength of the climate change dependent variable, but are not directly generating climate change outcomes by themselves. The presence of a strong leadership in local authorities is useful for strategic focus, long term vision, network articulation and also legitimacy to guide people toward urban innovation and sustainability development. Without citizens' involvement, urban projects are condemned to a short life and may limit social inclusion.

On the contrary, citizens' participation is a trigger of acceptance, maintenance and identity with climate change and future developments. In the case of urban institutes, the expertise and multidisciplinary team work and network are playing a role in the realisation of the mayor's urban vision to face climate change in real projects, facilitating stakeholder participation, diffusion and education, from the planning phase to the post-investments step of urban projects.

Policy implications

The model that emerges from this study contains five variables that can help cities in the implementation of urban policies to combat global warming. These should be considered in every proposal of any city that searches to implement a new type of urban planning, incorporating a new generation of urban projects aimed at mitigating climate change to achieve more resilient cities.

The proposed model can be applied to other cases of cities with the same characteristics or of different sizes and can study the evolution of the five variables that compose the model. The relative importance of each component of the model can be studied; for example, in the cases already studied, governance and urban institutes play a fundamental role in carrying out, in a short period of time, any urban policy, whether of planning or implementation of urban projects through urban rehabilitation strategies. In this case, governance would have a greater relative importance within the components of the model.

Another possible application in urban policies would be to transform the model into a self-assessment tool; for example, regional or local governments could detect the strengths and weaknesses in each of the components that prevent the implementation of urban policies addressed to mitigation actions for climate change in cities.

The model can also serve to build a ranking of cities and measure how well local governments are prepared to combat the effects of climate change, through the implementation of mitigation urban projects. It could also serve to explain the role of stakeholders (universities, neighbourhood associations, professional associations, etc.), in the implementation of mitigation measures in the various scales of projects and participation instances.

The model can be incorporated into public policies of short and medium term in local governments; for example, in municipal development plans based on the methodology of strategic planning and proposed by mayors for each four-year period of their term. Along with the above job descriptions of positions and functions for urban planners, who have the capacities to implement mitigation actions to climate change at all levels of urban planning, this model could be adapted to new realities and new challenges

On an academic level, the proposed theoretical framework can be incorporated into the urban planning curriculum in universities and other institutions of higher education.

Further suggested research

Future lines of researches that could be taken up include:

Studying the importance of incorporating mitigation and adaptation actions in urban projects to achieve more resilient cities. In the last ten years, research has been carried out on the concept of resilience, but the mitigation actions that are the basis for achieving adaptation and resilience of cities to climate change are not being considered.

Cities located in difficult geographical conditions, such as in coastal and desert areas, can be used for research. The cases studied correspond to subtropical regions within the continent and with a similar altitude and similar rainfall. Bearing in mind that a large percentage of cities worldwide and especially in Latin America are located in coastal or river areas, it is necessary to study possible mitigation and adaptation projects to protect cities against sea level rise or the increase in river flows.

Comparing similar Latin American cases with European cases, for example, the city of Bologna is developing a plan to adapt to the flooding of the Po River and the city of Livorno is thinking about sustainability and resilience in the face of climate change.

Finally the latest meetings of international organizations such as the Conference of the Parties COP during the United Nations Framework Convention on Climate Change, that took place in the Polish city of Katowice in December 2018, discussed the urgency of accelerating state-led actions on a global level to address climate change, and the IPCC 2018 climate report was taken as a basis for discussion, which indicated not to exceed 1.5 degrees Celsius global warming by 2030.

In this sense, local governments of the main cities of the world are called on to accelerate mitigation actions to climate change in order to reduce CO₂ emissions as soon as possible. This is a huge challenge for cities because time is running out and we do not know if we will be able to reverse the current situation.

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Appendix A Curitiba photographs

Photograph 28: Botanical Garden, the Stufa.



Source: author Photograph, 2014

Photograph 29: Lagoon Botanical Garden



Source: author Photograph, 2014

Photograph 30: Tub Bus station in a neighbourhood



Source: author Photograph, 2014

Photograph 31: Bus Rapid Transit



Source: author Photograph, 2014

Photograph 32: Bridge Wire Opera House



Source: author Photograph, 2014

Photograph 33: Lagoon under the bridge Wire Opera House



Source: author Photograph, 2014

Photograph 34: Free University of the Environment, lagoon and facilities



Source: author Photograph, 2014

Photograph 35: Historical centre



Source: author Photograph, 2014

Photograph 36: Historical building



Source: author Photograph, 2014

Photograph 37: Entrance Tub Bus station in Tradentes Square



Source: author Photograph, 2014

Photograph 38: Tub Bus station in Tradentes Square



Source: author Photograph, 2014

Photograph 39: Tub Bus station in Oscar Niemeyer Museum



Source: author Photograph, 2014

Photograph 40: Oscar Niemeyer Museum



Source: author Photograph, 2014

Photograph 41: De Tangua Park



Source: Simone Didonet, 2018

Photograph 42: De Tangua Park cave



Source: Simone Didonet, 2018

Photograph 43: De Tangua Park



Source: Simone Didonet, 2018

Photograph 44: Barigui park and river



Source: Simone Didonet, 2018

Photograph 45: De Tangua Lake



Source: Simone Didonet, 2018

Photograph 46: Barigui park, lake and promenade.



Source: Simone Didonet, 2018

Appendix B Medellin photographs

Photograph 47: Cable cars Natural Park



Source: author Photograph, 2014

Photograph 48: Overview from cable cars



Source: author Photograph, 2014

Photograph 49: Cable cars station and public space



Source: author Photograph, 2014

Photograph 50: Cable cars station, line K, in a neighborhood



Source: author Photograph, 2014

Photograph 51: Morro Moravia, integral urban project



Source: author Photograph, 2014

Photograph 52: Public space next to Morro Moravia



Source: author Photograph, 2014

Photograph 53: Morro Moravia small square



Source: author Photograph, 2014

Photograph 54: Reforestation Morro Moravia



Source: author Photograph, 2014

Photograph 55: Urban Park



Source: author Photograph, 2014

Photograph 56: Urban facilities within an urban park



Source: author Photograph, 2014

Photograph 57: Electrical escalators in a regeneration project



Source: author Photograph, 2014

Photograph 58: Public space with citizens participation



Source: author Photograph, 2014

Photograph 59: Facilities in a peripheral neighbourhood



Source: author Photograph, 2014

Photograph 60: Overview electrical escalators integrated to the neighbourhood



Source: author Photograph, 2014

Photograph 61: Facilities for children



Source: author Photograph, 2014

Photograph 62: Promenade in a peripheral neighbourhood



Source: author Photograph, 2014

Photograph 63: Library park San Javier.



Source: author Photograph, 2014

Photograph 64: Library park San Javier.



Source: author Photograph, 2014

Photograph 65: Square *Pies Descalzos*



Source: author Photograph, 2014

Photograph 66: Public Library and public space



Source: author Photograph, 2014