Shifting from a Risk Mitigation Project to an Adaptation Project: The case of Curitiba’s Lagoon Parks

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Abstract. Drawing upon the sustainability transitions theory, the paper aims to explore how the risk mitigation project of Curitiba’s lagoon parks shifted to adaptation urban projects in the context of tackling climate change. “Urban acupuncture” was the pioneering strategy adopted by Curitiba’s Municipality through the introduction, more than 40 years ago, of a limited number of low cost projects in some natural lagoons as innovative experiments that operate as a niche in a multi-level perspective. The projects acted as a way of resisting the pressure of urban intervention trends focused on transforming natural landscapes into new built-up urban areas, or intervention in natural ecosystems with water drainage and engineering solutions. These experiments and their synergy now constitute urban parks with a leverage impact on the capacity the city has to adapt to climate change, creating tension on the institutionalized regime. Through this case study, we examine the importance of governance, leadership and urban networks professionals in addition to technical features of the projects. The findings suggest that a top-down strategy, long time frame, and the exclusion of community participation have a limited likelihood of replicability and are discouraged nowadays in public urban policies. The paper contributes to highlighting the link between experimental urban acupuncture and sustainability transitions through incremental projects in natural areas for climate change adaptation. It contributes to the understanding of transitions in the southern hemisphere where institutions struggle with tight budgets, incremental interventions and specific nondemocratic contexts, and raises concerns about the critical role of governance.

1. Introduction

Scholars from transitions research argue that environment issues and societal challenges such as climate change, depredation of natural resources, and impacts of urban growth require solutions that are beyond the traditional technological-driven approaches given so far [1]. To tackle these phenomenon socio-technological shifts are needed, called sustainable transitions [2, 3]. The integration of social and technological systems is at the basis of this new stance [4].

Transitions scholars have contributed to understanding how interventions could be adopted to face these issues through a spectrum of levels, not going to the extreme of addressing radical changes through economic or societal logics for example (macro-level) or changes on an individual behaviour level (micro-level), but instead privileging sustainable transitions through an intermediate level, called meso-level of socio-technical systems that represent the unit of analysis [5]. In this case, these socio-technical
systems are defined as resources integrated by the sub-functions of production, distribution and the use of technology, and the linkages between them enable societal functions such as transport, communication or nutrition which need human actors organized in social groups for their operation, groups that have their own features, independence and potential interpenetration [6], thereby introducing the concept of socio-technical regimes [5].

In the case of climate change, cities are largely responsible for the impact of the Earth’s temperature increase of 0.8°C since the last century and roughly two thirds of this growth can be attributed to the time period since 1975. Cities are largely to blame for this situation [7] and constitute an attraction pole for rural populations, especially in Latin America. 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 [8]. Cities have adopted two main responses to tackle climate change: mitigation and adaptation. Mitigation strategies are twofold: one is oriented to reduce greenhouse gas emissions and is mainly focused on waste treatment projects, alternative generation of energy and public transport on an urban scale; the other is a strategy of risk mitigation as a consequence of the deterioration of natural systems brought on by human intervention (anthropic) or for natural causes. On the other hand, adaptation strategies are focused on developing infrastructures that minimize the negative impact of climate change on rising sea-levels, floods, and changes to rivers through green and blue infrastructure.

However, research about cities’ sustainability transitions is mainly addressing European experiences and studies at an urban scale rarely combine both strategies. Therefore, this research aims to explore how mitigation and adaptation strategies on an urban scale facilitates the production of a sustainability transition in a Latin American context through projects implemented more than four decades ago. We argue that the “urban acupuncture” experiment introduced in Curitiba in the 1970’s is unique and although it has not been originally framed in the context of climate change it is a representative experiment of the South engaged in Grand Challenges, sustainability transitions, and public policy interventions. To that end, we introduce the case of Curitibas’ lagoons project and ask how an initial risk mitigation project shifted to an adaptation urban project for climate change based upon sustainability transitions.

This article contributes to the growing literature of sustainability transitions in urban contexts in a more operative way by analysing the experiment of Curitiba through the role of implemented projects in the management of climate change. It contributes to extending the knowledge about the blurred relationship between mitigation and adaptation on an urban scale and raises the importance of context to understand how some policy strategies such as “urban acupuncture” were possible.

The article’s structure is as follows. The first section briefly presents a literature review of the existing research from a sustainability transitions perspective and of mitigation and adaptation urban projects for climate change with specific references to cities and climate change issues, urban planning, urban governance and urban projects for mitigation and adaptation. Secondly the case study is introduced followed by the main findings, the discussion in relation to the sustainability transitions theories and the case study replicability and conclusions.

2. Literature review
2.1. Sustainability transitions
In the past two decades sustainability transitions research has developed different frameworks which acknowledge that transitions are non-linear processes and reflect its interdisciplinary and broader
approaches such as the multi-level perspective (MPL), the technological innovation system approach (TIS), strategic niche management and transition management [9].

One of the most diffused frameworks is the multi-level perspective which states that sustainable transitions are the consequence of dynamic processes which operate on, and between, three different levels [10–12]. A first level is called niches which is represented by limited and protected spaces where radical innovations can happen through the interaction of actors who are oriented towards working on experimental and demonstration projects that are distinct from regimes. The second level called socio-technical regime gathers institutional structure and institutionalized systems that guide actors contributing to path dependence and incremental change. The third level, the socio-technical landscape, is integrated by a broad context that has influences on the regimes and niches through ideologies, values, and infrastructures. Niches are able to produce changes if the tensions between stability and change can be balanced due to the pressures of landscapes on the regimes, which interpret changes as either a threat or a window of opportunity, and develop different types of reactions [5].

The TIS analyses the integration of technologies, actors and institutions and advocates that networks of agents are at the origin of novel innovations and produce, diffuse and use technology. These networks are in contact with economic or industrial systems that obey a specific institutionalized infrastructure [13–15].

The strategic niche management is centred on the analysis of radical innovations based on sociology of innovations and evolutionary economics with a special interest on the relationships between the learning processes, social networks, visions and expectations [16, 17].

On the other hand, transition management [18, 19] emerged in a policy-oriented context. Policy makers are potentially agents for shaping transitions through four sequential steps described in an S-curve development [18]. A first step called strategic activities in a transition arena has the objective to define a vision and pathway alternatives. The second step of tactical activities has the purpose of building specific plans and defining networks and budgets. The third step is related to operational activities that are directly tangible and implement innovation experiments with a learning-by-doing component. The fourth step, called reflexive activities, is connected with monitoring and assessment, and should reinforce or adjust the previous steps through its best-practices.

2.2. Mitigation and adaptation urban projects for climate change
2.2.1. Cities 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 [20]. 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.

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 [21]. In 2014 international organizations such as the IPCC (Intergovernmental Panel on Climate Change) insisted on the concept of mitigation as a human intervention that aims to reduce the sources and improve the sinks of greenhouse gases, avoiding anthropogenic interference with the climate system. This could allow an adaptation of ecosystems to ensure food production and seek a more sustainable economic development [22]. 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".
According to Fernández-Reyes [23] and international organizations such as the IPCC for the years 2007-2013, and the Comisión Económica Para América Latina y el Caribe (CEPAL), 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 2017, UN Habitat once again insisted on the dangerous effects of the accelerated urbanization of cities and their relationship with climate change. 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 [24].

2.2.2. Mitigation, adaptation, and urban planning

The actions on a 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 [25]. 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 Rio de Janeiro in Brazil [26]. Other cities like Bogotá, Mexico City and Santiago have also been investing in mitigation actions with a high level cost to face temperatures, flooding and mass movements [27].

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 [28]. Years later, authors recommended the need to incorporate mitigation and adaptation to climate, in the "spatial planning" of cities, as an important consideration due to the growing attention of the scientific, political and social world to climate change. During this period, spatial planners were challenged to include climate change considerations in the city planning process [29].

In 2014, a report by the Organization for Economic Co-operation and Development (OECD), Cities and Climate Change - National governments enabling local action, affirmed that by applying effective urban policies through urban planning instruments, cities can influence the good design of infrastructures so they can withstand the expected increase in climate change. Another important concept that emerges from this report is integrated urban planning, which is fundamental for the change of land use, infrastructure, and 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.

Besides, 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 [30].

2.2.3. Urban governance

In 2014 UN-Habitat report, Planning for Climate Change: A strategic, values-based approach for urban planners, 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. 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. 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 [31].

Swilling et al. [32] identify six types of urban government and there may also be mixed typologies. Some examples of good governance can be found in Latin American cities like Bogotá which has been praised for its rapid bus transit system, known as the TransMilenio, and its cycle paths. 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 [33].

2.2.4. Urban projects for mitigation and adaptation

Urban projects face new challenges today; they 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 new type of projects for a new generation that must strongly incorporate mitigation actions to climate change [34].

According to McAndrews et al. [35] 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. Cervero [36] 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.

According to Demuzere et al. [37], 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. According to Mathews et al. [38], 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 [38].

Considering the urban projects as part of the urban planning, we present a framework that integrates the two types of projects contributing to climate change, a first group of mitigation urban projects targeting CO₂ reduction and risk mitigation and a second group of adaptation projects that can be related to risk mitigation endeavours. The outputs from projects focused on Green gas emissions and adaptation are "actions planning for climate change" that we present in Figure 1. Risk mitigation projects are originally developed out of the context of climate change (to face catastrophic impact of natural anthropic or disasters). The new scenario of climate change threat is forcing the transition from risk mitigation project to an adaptation project which explain their indirect role on climate change.

3. Curitiba as a case study

Curitiba is located in South Brazil with 1.9 million inhabitants approximately [39] and 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 covering an area of 435 km² [39]. 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 to above 30°C on the hottest days. There is an annual average of 1,500 mm of rainfall [40].

![Figure 1. Urban projects and climate change (Source: own elaboration).](image)

Due to the concern for the future effects of climate change and how they affect urban functions, the municipality of Curitiba proposed a climate change programme whose strategy was to "develop and apply a policy aimed at mitigating greenhouse gases on 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” [41].

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. 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. During Jaime Lerner’s first term as mayor (1971-1975), 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" [42].

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. To placate the resistance, 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" [42].

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.

In terms of urban context and its urban projects, Curitiba has several features that are unique and are related to 8 main areas: 1) its strategic and territorial planning and risk issues through urban planning instruments, 2) governance in relation to major leadership, 3) characteristics of urban projects that shifted into mitigation urban projects, 4) main mitigation urban projects for gas emissions and the natural risks, 5) the impact of mitigation urban projects on climate change, 6) the relationship between urban projects and natural risks to climate change adaptation, 7) the integration of urban projects integrated into urban planning and 8) main achievements and challenges. Each of these features are presented in the Table 1.

| Table 1. Main features of the Curitiba case (Source: own elaboration). |
|---------------------------------------------------------------|
| **Strategic and territorial planning and risk issues developed in urban planning instruments** |
| In 1943 the *Agache Plan* 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. |
| **Governance, innovation and leadership role of mayors. Institutions included. The way that climate change issue was incorporated.** |
| 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. |
| **Characteristics of urban projects to be transformed into mitigation urban projects** |
| Public transportation known as BRT articulated buses in dedicated bus lanes, 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". |
| **Mitigation urban projects for gas emissions and the natural risks** |
| 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. |
| **Mitigation urban projects contributing to combat climate change** |
| 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. |
Table 1. Continue

| Mitigation urban projects connected with natural risks related to climate change adaptation projects |
|--------------------------------------------------------------------------------------------------|
| Cultural parks with small ponds (e.g. Free University of the Environment and Opera di Rame) and large urban parks with lakes and rivers (e.g. De Tangua Park and Barigui park) are all 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. |

| Mitigation urban projects being integrated into urban planning |
|---------------------------------------------------------------|
| 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. |

| Main achievements and challenges |
|----------------------------------|
| 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. 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. |

4. Discussion

The aim of this research was to explore how mitigation and adaptation strategies on an urban scale facilitated the production of a sustainability transition in a Latin American context through projects implemented in Curitiba more than four decades ago. The acupuncture strategy adopted in the 1970’s in Curitiba is the product of the mayor’s vision of the city, with its planning process, implementation and reflective process. In fact, the acupuncture strategy [42] can be assimilated to the sequential steps described in an S-curve development of transition management [18] where mayor Jaime Lerner played a leading role as agent of change in this urban policy orientation.

On the other hand, the lagoon projects were implemented over several decades and were innovative in terms of their tight budget and resistance to urban trends of changing the land use of ecosystems in new human settlements under the pressure of the migration of rural populations. The mayor resisted the practice in place in many cities of draining water through engineering infrastructure with high investments, and instead prioritized the maintenance of natural landscapes to act as tools of risk mitigation management. The innovation introduced in this niche highlights the work of Lerner and the Institute for Research and Urban Planning that experimented and implemented these urban projects that were so distant from existing regimes. A top-down model was applied in the 1970’s and 1980’s in Curitiba in accordance with the dictatorial national political system in place at that time. More recently, this top-down strategy evolved towards citizen participation in parallel to the democratization of the country. Nowadays, actions applied following a top-down model have a high probability of failing and it is suggested that representation of non-institutional actors, especially non-governmental organizations, should be included under the bottom-up modality [43].

This case study enables to highlight the importance of issues related to 1) strategic and territorial planning, 2) governance and the leadership of the mayor who innovated with his strategy of urban acupuncture, and 3) the shift of risk mitigation projects to adaptation urban projects. Risk mitigation projects such as lagoon parks are oriented to mitigating river overflows as a consequence of torrential rains. These risk mitigation projects were located in areas outside of pedestrian uses and a long way from human settlements, and unless little investments in facilities were made, they would have
maintained the single and unique role of risk mitigation. Thus, the innovation of building cheap facilities (e.g. Free University of the Environment and Opera di Rame) enabled to activate a new role, transiting from the initial risk mitigation project to an urban park network. Moving forward, once climate change issues began to be recognized as an urgent challenge that was already impacting sub-tropical areas such as Curitiba, the city took advantage of the initiatives developed many decades ago in the same lagoon parks. An adaptation climate change plan was adopted that includes the lagoon parks as projects with a new role of adaptation to climate change due to increasing rains and floods that were registered and projected in the next 50 and 75 years. The transition in the niche [10] was possible because of several innovations of urban acupuncture and the enrichment of the roles of projects, transiting from mitigation risk to adaptation in a new landscape scenario where climate change was defined as the world’s most important challenge, and for which cities are both the problem and the solution.

However, we argue that the transition from a risk mitigation project to an adaptation project is neither guaranteed nor linear [16]. Thus, the risk mitigation projects depicted in Fig. 1 are not automatically shifting to adaptation and only some of them have that potential such as Curitiba’s lagoon parks because of their unique features in terms of transition management [18] through urban acupuncture, urban planning and governance.

Future research may explore other cities’ paths to sustainability that not necessarily have a strong starting point in risk mitigation projects and on the contrary have initially invested directly in adaptation strategies. To what extent other risk mitigation projects have the likelihood to transit to adaptation and what kind of balance between mitigation and adaptation strategies is needed is also an area that could be studied.

5. Conclusions
The article has attempted to understand how the risk mitigation project of Curitiba’s lagoon parks shifted to adaptation urban projects in the context of tackling climate change based on sustainability transitions theory. Drawing upon the sustainability transitions through both multi-level and transition management perspectives, the research explored the case of Curitiba which more than four decades ago initiated a process of transformation through the innovation strategy of urban acupuncture led by Jaime Lerner, Curitiba’s mayor at the beginning of the 1970’s. The originality of lagoon parks is that they are an example of risk mitigation projects that transit to adaptation projects for climate change. In effect, in the 1970’s, the natural lagoons of Curitiba were maintained as ecosystems with a mitigation risk role against the regime tensions and later when climate change issues gained consensus and were recognised by the scientific community and by policy makers, the lagoon parks were integrated into the city’s adaptation climate change plan because of the increasing threats of climate variability.

The research highlighted that the early implementation of risk mitigation projects like lagoon parks offered the city the advantage of being able to shift these projects to climate change adaptation projects once climate change was defined as the major challenge cities are facing. This finding suggests that more research may explore the balance between risk mitigation and adaptation urban projects.

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