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Implementing climate change adaptation actions in the Metropolitan Region of Santiago (Chile)

Name: Alexandra Narr

Supervisor: Dr Alberto Gianoli

Specialisation: Urban Environment, Sustainability and Climate Change

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Institute for Housing and Urban Development Studies of Erasmus University Rotterdam

Summary

This thesis investigates the main drivers that support the implementation of climate adaptation initiatives in the Municipalities of the Metropolitan Region of Santiago, Chile. The research aims to discover which of the three factors mentioned in academic literature (Framing, Political and Local Governance capacities) have greater predominance and play a fundamental role in climate change adaptation. Therefore, the current state of Municipalities regarding climate change adaptation is examined and analysed to see how local governments are implementing adaptation initiatives. Then the main factors contributing to the implementation were studied. Thus, the main research question of the thesis is: Which factors enable the implementation of climate change adaptation initiatives in Chilean metropolitan municipalities?

The strategy for achieving this objective consisted in a combination of different analyses. Firstly, a desk research was developed by reviewing main policies and instruments to evaluate the current adaptative climate situation in the Metropolitan Municipalities of Santiago. To complement this information a survey was conducted with the purpose to go in depth by investigating the factors that were considered fundamental by Municipalities. Lastly, a Qualitative Comparative Analysis was performed. This approach enables to investigate cases and the conditions that may cause an outcome, in this case, the implementation of adaptation initiatives by assessing equifinality. Part of this analysis include the review of the three cases study, facilitating the interpretation of the model.

The main findings of the research underline the important influence of the driver *development of Climate Adaptation Plan* as a sufficient and necessary condition to the implementation of climate adaptation initiatives. Through the case studies it was revealed that having one of these plans implicitly contained other highly relevant factors, such as trainings, staff, cooperation through subsidies/programs, legislative support, commitment, and participation in climate change networks. Further, the current state of municipalities revealed that the largest number of implementations actions were carried out from municipalities that count with these plans.

Thus, based on the results of the model and the information gathered from official municipal documents and plans, the main recommendation for mayors is to prioritized climate change and address it by developing a climate adaptation plan whereby they can address main risks and vulnerabilities and achieve the implementation of action in its territories in a transparent and effective manner.

Keywords

Climate change adaptation, climate action plan, implementation drivers/enablers, Municipalities, Metropolitan Region of Santiago

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Abbreviations

IHS	Institute for Housing and Urban Development Studies
MRS	Metropolitan Region of Santiago
CAPL	Climate change adaptation plan
CCA	Climate change adaptation
GHG	Greenhouse gas
LES	Local energy strategy
PLADECO	Community development plan
QCA	Qualitative comparative analysis
fsQCA	QCA software
RedMuniCC	Municipal climate change network
IPCC	Intergovernmental Panel on Climate Change
SDG	Sustainable Development Goals
OECD	Organisation for Economic Co-operation and Development
UNFCCC	United Nations Framework Convention on Climate Change
INE	National Statistics Institution Chile
UN	United Nations
PPP	Public private partnership
ISO	International Organization for Standardization
INE	Institute of National Statistics

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Chapter 1: Introduction

1.1 Background Information

More than 50% of the population lives in cities, with projections expected to reach 60% in 2030. Urbanization in all size classes is expected to increase, while rural settlements are expected to decrease (UN, 2018). This urban agglomeration brings out citizens exposure to natural disasters, due to the fact that 59% of the world's cities have a high risk of exposure to natural hazards, such as earthquakes, droughts, flood, among others (UN, 2018). On the one hand, this vulnerability increases because humans' customs and consumption patterns enhance green gas emissions (Klopp & Petretta, 2016). On the other hand, cities are seeing as drivers to boost sustainable development by providing efficient services, innovations, and opportunities to adapt and mitigate climate change effects (Klopp & Petretta, 2016). An historical commitment, that represented a huge milestone in history by putting cities in the centre path for a sustainable development, was the Paris Agreement in 2015, were United Nations, professionals, urbanism, and the civil society recognizes the importance of cities for facing climate change. This culminated in the development of the New Urban Agenda and the 11th goal of the 2030 Agenda for Sustainable Development "Make cities and human settlements inclusive, safe, resilient and sustainable" (Kristie, 2015 p.26).

In this context is that local governments started to have an active role in climate change by approaching mitigation and adaptation plans (Araos et. al, 2016). Nevertheless, unlike mitigation measures that have suitable tools and baselines, the case with adaptation is different and challenging thus no clear standards and methodologies have been establish (Ford et. al, 2015; Ford et. al, 2010). Further, many cities across the globe are working in climate change adaptation plans, but only 18% of them are implementing them (Araos, 2016; Carmin et al., 2012). With this in mind, the following question arises: how can local governments defeat barriers to increase the implementation of climate change adaptation initiatives? It is a concerning question, especially in the south hemisphere where Carmin et al. (2012) found that, after analysing 468 cities, Latin America has the highest engagement in adaptation planning (95%), while as mentioned before, this percentage is far from what is being implemented.

In recent years, literature has analysed which are the main factors that influence the implementation of adaptation initiatives. For this, it must be understood that adaptation considers policies, goals, objectives, instruments, and agents. The instruments are key in the implementation since they are the elements that governments use to make a change and/or influence the behaviour of their objectives to achieve their goals (Henstra, 2016). Some of the instruments used are training, taxes, loans, regulations, subsidies, laws, voluntary agreements between governmental and non-governmental groups (Howlett, 2005; Mees et al., 2014; Henstra, 2016; Stead, 2018; Biesbroek and Delaney, 2020). Adaptation differs according to the context, so being able to identify which factors are the most used in a certain territory serves to understand how governments are setting their goals and implementing their preferences.

Factors are the elements that directly and indirectly influence, by boosting or constraining, the implementation of climate adaptation actions. There are several authors that signal **local government capacities** as fundamental to the development and implementation of climate policies. Capabilities such as resources, organizational and cognitive factors are crucial for analysing and understanding how municipalities are implementing adaptative initiatives. But there are other factors that go beyond local authorities, especially in metropolitan areas, where policies are subject to numerous policy instruments depending on jurisdictions and government levels (Ryan, 2015). Therefore, local capacity can be considered the main and direct factor for implementation, but there are other factors that have been studied and might indirectly

influence implementation as they have an impact on the capacities of a local government. One of these factors is **framing,** which aim is to "open up public dialogue and help bridge political divisions over policy actions at local scales, to complement national and international efforts. Opening up public dialogue may improve engagement to manage climate change issues through local governance" (Romsdhal, 2020, p.147). As framing, **political factors** also influence the municipality's capacity to face climate adaptation, as the role of political leadership, willingness, and commitment from authorities (Ryan, 2015; Rundhaar, 2018).

1.1.1 Climate Change and Adaptation in Chile

Chile is vulnerable to climate change and its effects can be already being felt at the national level. Climate projections for the country, until 2030, show the increase in temperature in at least 1,5°C and a decrease in rainfall from 5%-20%, as the main effects (Farías et al., 2017). Increases in the frequency of extreme events such as droughts and flooding in both river and coast are also being expected. All these changes have direct effects on most of the country's productive activities, as well as the sustainability of the nation by affecting the social, environment and economic aspects of the state.

Being aware of this, the government has worked on several strategies to overcome these hazards, developing a National Climate change plan (2017-2022), National Climate Adaptation Plan (2014) and Sectorial Climate Change Adaptation plans (Forestry, Biodiversity, Fisheries and Aquaculture and Health Sectors, Cities, Infrastructure, Energy, Tourism and Water Resources), among others.

As seen, Chile has been active in the execution of multilateral programs and mechanisms following UNFCCC guidance. However, the implementation of actions to achieve those goals hasn´t succeed as expected. From the mitigation actions, a 50% has been achieve but regarding climate adaptation initiatives only a 12% have been implemented (Ludeña et al., 2015).

1.1.2 The context of the Metropolitan Region of Santiago (MRS)

In the last years, the MRS has documented seven heat waves, making the summer of 2020 the warmest since 1950 (Montes, 2020). Further, the lack of rain has been particularly extreme in the surroundings of Santiago, with a level of precipitation between 10% and 20% (Llorente, 2020). Another threat that impacts the region is smog, which increase with factors as the urban heating and the use of urban transport (National Library of Chile, 2018). This area is also highly agglomerate (population of -7 mill inhabitants, a 37% of all country population) and conformed of 52 municipalities with significant differences in terms of income, geographical and spatial features. In front of this vulnerabilities, according to the Chilean Climate Change Network (RedMuniCC, 2020), local governments that have acted and developed a Climate Change Adaptation Plan (CAPL) are only 15. This low number of CAPL, could be explained due the barriers that local authorities face nowadays, were some of these are economic resources, governance system, short and long-term vision, and political willingness (Aldunce & Vicuña., 2019). These obstacles affect the way municipalities develop their actions plans and once they have it, it disturbs the implementation of them.

1.2 Problem Statement

While there is vast academic and scientific knowledge verifying adaptation is essential for tackling climate change and decrease cities vulnerabilities, obstacles on adaptation plans, laws, programs, and measures are evident. Tackling adaptation is complicated, since dealing with wicked problems such as climate change and the understanding of societal vulnerabilities, are not easy issues to encompass (Krellenberg & Hansjürgens, 2014). Urbanization and climate

change are ongoing interconnected processes. In Chile urbanization grows annually at a rate of 2.2%, and the MRS harbors almost 40% of the country citizens (INE, 2019). Regarding climate change, the MRS is a generator of greenhouse gas (GHG) emissions from its direct and indirect activities, as well as a direct affected territory of the environmental effects and impacts in different sectors, such as industrial, residential, and agricultural. The expected impacts of climate change are low precipitation and temperatures surges, which have direct implications in the availability of water, floods events, fires, and heat waves (Vicuña et al., 2017). Even though there are adaptation climate plans at a national, sectorial, and regional level, at the local territory, progress is unequal. There are some local governments that have incipient progress regarding climate change, while others are still designing CAPL, with different levels of adoption among them. The key question is: are they being implemented? there is a challenge in action's implementation. These situations generate questions about how adaptation is being designed and structured, both at national and local level, since they have permitted the generation of a notorious gap among municipalities. Some possible explanations could come from the lack of political leadership, or no legal binding at a local level (Hall & Persson, 2018). Thus, municipalities can voluntarily develop climate change adaptation plans, but there is not a commitment for tracking those actions. Therefore, no formal commitment regarding implementation con be established. Furthermore, Ryan (2015) emphasizes the lack of local framing as a limitation to support local adaptation action.

Local capacity seems to be under the literature body as the main factor that contributes or constraints implementation, hence understanding adaptation drivers and their implications are essential to understanding implementation of climate actions (Biesbroek et al., 2020). Further, identifying the current status of adaptation measures in the municipalities of MRS is key to understand which factors are crucial for boosting implementation.

1.3 Research Objective

As metropolitan municipalities in Chile differ substantially in terms of progress regarding climate change adaptation initiatives, the aim of this study is to evaluate and explain which are the main factors that influence the implementation of adaptation actions in local governments.

This objective is achieved by analyzing the differences among the current adaptation state of municipalities in the MRS by evaluating the implementation of actions by type, sector, and status. Further, the factors that facilitates the implementation of adaptation initiatives are explored through the development of an analytical model (Qualitative Comparative Analysis) and the analysis of three case studies, getting in-depth insights that could be helpful to understand which factors drive climate adaptation.

1.4 Main research question and research sub-questions

In order to address the research objectives, the main and sub-questions are:

Which factors enable the implementation of climate change adaptation initiatives in Chilean Metropolitan Municipalities?

- What is the current state of municipalities in MRS regarding climate change adaptation?
- How is adaptation being implemented?

- Which are the main framing, political and local capacity factors that MRS municipalities should consider for implementing climate change actions?

1.4.1 Significance of the study

The effects of climate change are increasing and the need of cities to reduce vulnerabilities and reinforce resilience are latent through adaptive measures (Owen, 2020). McNamara and Buggy (2017), defined climate change adaptation as the capacity to face hazards and have a positive outcome through a present or future response to climate impacts, throughout the regulation of the environment and/or the system. There are numerous plans and strategies that cities have developed displaying leadership in the matter, but there is little investigation on how cities are implementing adaption initiatives (Araos et al. 2016). Respecting this, Biesbroek et al. (2020) emphasized in the current gap that exist regarding climate change and adaptation actions, and how this outcome suggests strengthening the adaptive implementation initiatives.

In this context, this analysis contributes to the academic knowledge by building on previous and significant studies in the field of climate change adaptation with aim to reduce the gap regarding the implementation of adaptive actions in Chile. It explores and relates the factors that worked as facilitators for the implementation of adaptive actions in a country of the south globe, contributing to the scientific knowledge in local government in the region. Furthermore, it could help guide different actors related to urban development, by providing information that might be applicable for adaptation policies and initiatives in terms of implementation actions, by making cities more resilient and less vulnerable.

Chapter 2: Theory Review

2.1 Climate change adaptation

Climate change adaptation can be defined as the capacity to face impacts and answer positively to actual and future effects of climate, through the regulation of the environment and/or the system (McNamara and Buggy, 2017). In other words, adaptation addresses the consequences of climate by diminishing the exposure to current and upcoming hazards, meaning adaptation deals with uncertainties. This ambiguity is directly linked with the concept of climate change, which is described as a wicked problem with multiple inputs and outputs within the interaction of humans and nature (Sun et al., 2016). This complex scenario makes cities vulnerable to climate change, and even more if cities growing rates are expected to keep rising, therefore more people will be exposed to climate hazards such as high temperature, droughts, floods, wildfires among others (IPCC, 2012). Furthermore, urbanization and climate change doesn't only affect cities, on the contrary, cities are seeing as the main contributors to solve negative impacts, due the resources and capabilities that they developed (Grimm et al., 2008). Therefore, there is an inherent need to work on climate adaptation within cities to reduce cities exposure and ensure human well-being. In this context, municipalities play a pivotal role in adaptation. According to Ford et al. (2010), 67% of adaptative initiatives are implemented at this governance level. The benefits of adaptation are multiple, such as increase in adaptive capacity, increase in resilience, and decrease in vulnerability, all of them under a specific context to ensure an effective approach (Owen, 2020).

Although, adaptation is recognized for years as essential to combat climate change and in the present is integrated in different policy instruments, it has always had a challenging component that complicates the comprehensiveness and evolution of it, probably because of its complexity. From the early beginnings, Kates (1995), wrote about the uncertainty of adaptation. According to his studies, two scientific doctrines were responsible for the lack of attention the concept received: the preventionist and the adaptationist. On the one hand, preventionist were focus on mitigation and the relevance that GHG's achieve in eyes of society, making any work related with adaptation irrelevant. On the other hand, adaptationist thought that climate change would occur slowly, and nature and humans would have enough time to recover with no need to rush on it. Twenty-six years later, the consequences of the lack of concern that was given to this concept is visible. Cities all over the world are facing droughts, record high temperatures, increasing water scarcity and flooding. Owen (2020) developed a literature review to evaluate the status of climate change adaptation worldwide. Although there is an unquestionable progress regarding adaptation and Kates schools of thoughts can rarely continue to exist, Owen detected challenges that are undeniable. There are many adaptation strategies and plans, but there have hardly been implemented. Further, more than half of the articles about adaptative implementation are focus on Europe and North America and only 10% in South America. Moreover, adaptation is shaped by its context, making difficult to replicate or evaluate the same initiative in different territories and expecting matching results. Though there are many scientific and academic advances and studies related to climate adaptation, there is still some confusion regarding how to encompass this field.

2.1.1Adaptation initiatives

There are different actions that local authorities can develop to decrease city's vulnerability. From hard-infrastructure solutions as improvement in drainage systems for flooding protection, to green-blue infrastructure by strengthening the ecosystem from high temperatures. Furthermore, soft-infrastructure, a people-oriented approach, is focus on the development of capabilities to ensure cities resilience such as coordination among institutions, adaptative mainstreaming and engage and raise awareness in communities (C40, 2016). Moreover, Klein (2003) inquires in the fact that adaptation can be apply in current and future conditions by classifying adaptation measure in anticipatory and reactive types, being the first a response before an impact occurs and reactive, when an impact has already taken place. He also studied a second condition that depend on the system where adaptation can be originated: natural system, that for default requires a reactive reaction, and human system, which could be both actions: anticipatory and reactive. It also makes the difference between the role of public and private sector. Details are observable in *Figure 1*.

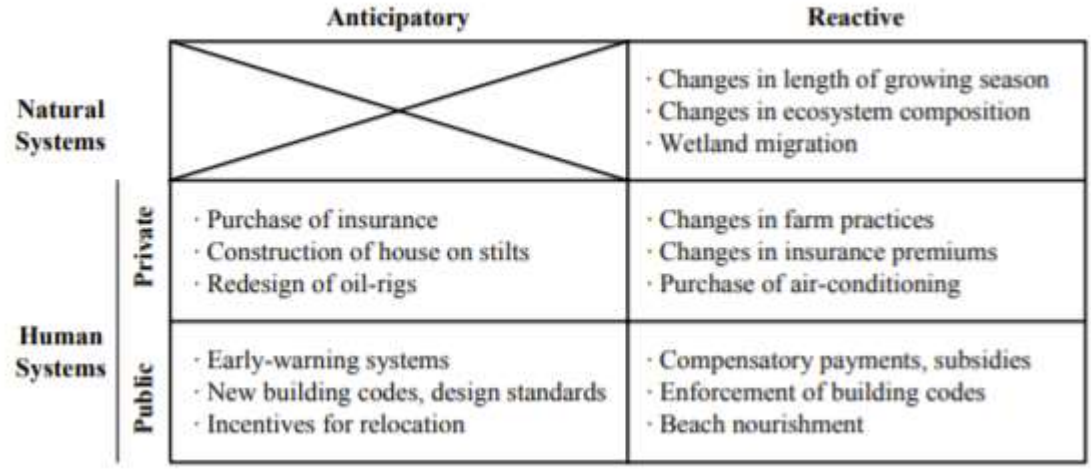

Figure 1: Matrix of five prevalent types of adaptation to climate change (Klein, 2003)

An insight study was developed by Lesnikowski et al. (2013) since it emphasizes two types of actions; by drawing a line between the actions on the early stage of development and the ones that have already advanced to the implementation phase. On the one hand, Groundwork level initiatives are the ones focused on the early stage of adaptation where the aim is to understand, inform, and prepare cities in front of climate hazards. On the other hand, adaptation level action are initiatives that are implemented into concrete tangible actions to enhance resilience in a city. *Table 1*, describe examples of types of action in both classifications.

Table 1: Adapted from Lesnikowski et al., (2013)

Groundwork level actions	**Adaptation level action**
Impact and vulnerability assessment	Organizational development
Adaptation research	Regulation
Conceptual tools	Infrastructure/technology/innovation
Climate change scenarios	Public awareness and outreach

Stakeholder's networking	Surveillance and monitoring
Policy recommendations	Resource transfers and financial support
	Performance reviews of adaptation progress

2.2 Adaptation policies

In the Fifh Assessment Report of the IPCC, policy is identified as a key adaptation opportunity in terms of integration of resources and infrastructure, spatial planning, and the establishment of standards. This condition "represent enabling factors that enhance the potential for actors to plan and implement actions to achieve their adaptation objective(s) or facilitate adaptive responses by natural systems to climate risk" (Klein et al., 2014, p. 908). Henstra (2016) conceptualizes public policy as the action that governments take in front of a problem which compromise desired outcomes, the involvement of different stakeholders, policy instruments, tools to change conditions, and agents that use those tools to implement policy targets. As seen, there are many variables and steps in a policy process (*Figure 2*). The process itself is well established and should be constantly feeding back. However, as we saw previously, adaptation is complex, and implementation face several challenges that will be covered in the next sections.

Figure 2: Adapted from The European Climate Adaptation Platform Climate-ADAPT (2015)

2.2.1 Policy instruments

Policy instruments play a fundamental role in adaptation, since they are the tools used by governments to implement climate policies (Biesbroek et al., 2020). There are different types of tools. Based on the literature review developed by Bouwma et al. (2015), there are five principal types of instruments: legislative/regulatory, economic/fiscal (taxes, subsidies), agreement based/co-operative (PPP's), information/communication (one way communication i.e eco-labelling) and knowledge-innovation (exchanging best practices). In practice, it is common to see that most policies have more than one instrument. Additionally, many policies

are interconnected with one another, or refer to other policies to cover certain topics. This is the case of adaptation action plans, a climate action tool which has been gaining popularity in recent times and it's seen as an ally when it comes to implementing climate adaptation actions (Climate-ADAPT)

2.2.2 Climate action plans (CAPL)

Part of the efforts made by different entities at the international level is to promote the development of climate adaptation plans. The aim is to promote a plan that allows identifying the main areas of action to achieve resilience and reduce vulnerabilities to climate change. It is worth mentioning that the development of adaptation plans should not be isolated from existing urban policies, therefore, sector policies, strategies, managements, processes, and existing structures of organizations should be considered. Climate adaptation by nature is transversal, therefore must be mainstreamed in other sectoral policies such as health, education, water, transport, security, among others. This cross-cutting characteristic is perhaps the most complex aspect of creating an adaptation plan, since it is necessary to work hard to be able to integrate the existing strategies, which is challenging since it involves the coordination, cooperation, and participation of a numerous actors (World Bank, 2019; Climate-ADAPT).

Last studies about climate adaptation policies show that policy mixes are a robust way to analyze and compare adaptation among cities. Lesnikowski et al. (2019), developed a research where, for the first time, a way to compare adaptation policies, independent of the different levels of government or political sectors was found. The study developed a useful outline for tracking adaptive policies, since as mentioned before, climate action plans and the other multiple policies at a national, regional, and local level, sometimes overlapped. Furthermore, countries differ with respect on governance features and aspects. Therefore, being able to analyse and compare them serves to a better understanding on how adaptation is taking place.

2.3 Implementation of adaptative initiatives

As mentioned before, policy instruments are tools to implement policies which can consider actions ranging from taxes and communication to the development of human capabilities. For aims of this study, **implementation of Climate adaptation initiative** can be defined as a project, regulation, information, or program that is translate by the municipality into a concrete action.

Implementing adaptive initiatives is not an easy task, is a process whereby several actors and institutions are involved that mark a trading point from an intention into a concrete action. Kahn (2016) identifies three sub steps in the implementation phase, which he called: "(1) output, outcome, and ultimate outcome of policy; (2) impact of policy; and (3) measurement whether the policy leads to the development of country/society as a whole" (Kahn, 2016 p.7). As seen, the adaptation policy process is already difficult with different steps and actors, and the implementation process itself as well. Hence, it can be understood that today there is much uncertainty regarding these issues, even more if both are combined.

Regarding adaptation instruments studies are evolving but is still an emerging field research. Last year, Biesbroek et al. (2020) mapped policy instruments in Europe and discover that more than a half of the instruments analysed were imprecise, giving broadly references of which type of hazards and impact were trying to mitigate. Recent studies have used NATO assessment from Christopher Hood (1983) to analyse policies and its instruments (Biesbroek et al., 2020, Lesnikowski et al. 2019, Henstra 2016), which seems to be the most robust governance approach for climate adaptation for now, by dividing policy instruments into four essential

resources: Nodality (disseminate, generate and mobilize knowledge to inform about adaptation), Authority (use legitimate power to boost or constrain adaptation action), Treasure (public funding to incentives adaptation actions) and Organisation (government resources and staff to implement adaptation actions) (Henstra, 2016). Moreover, recent studies conclude that most of the research regarding implementation of adaptation actions are focus on European cities from a cross-sectorial point of view and encompassed by local governments (Biesbroek et al. 2020, Lesnikowski et al., 2019) stressing out the importance in developing more general and suitable outputs, to serve as guidance for local authorities all over the world.

The need to develop generic assessments and standardization for implementing climate adaptation is broadly discuss in literature. This necessity was the reason that recently gave rise to a concept known as Tracking Adaptation. This new research field emerge as a response to the lack of clarity, regarding a common assessment to evaluate the progress of climate change adaptation. It can be defined as "a subcomponent of monitoring and evaluation that seeks to systematically identify, characterize and compare adaptation across nations or cities and over time" (Araos et al., 2016 p. 375). According to Ford et al. (2016), this concept gained more relevance during last year's due to the increase in investment funds for climate adaption all around the world, and therefore the need to translate ideas into concrete actions. Furthermore, different actors at different city levels and sectors are showing more interest in tracking adaptation to identify climate priorities, allocate resources, provide transparent information status, and analyze if support given is being turned into actions. In a study about implementation progress on adaptation, Lesnikowski et al., (2015) relied on this concept.

In this context, is that Ford et al. (2016) with aim to have a framework of adaptation tracking, developed four requirements, commonly known as 4C's, that already have been used in the analysis of climate adaptation policies and its implementation (Araos et al., 2016, Lesnikowski et al. 2019): *Consistency* seeks to conceptualized the definition of adaptation to facilitate the comparison of initiatives through a common and shared understandable concept. *Comparability* aim is to have spatial and temporal units for analyzing; *Comprehensiveness* looks for available datasets across different countries, regions, city levels and sectors. Finally, *Coherence*, aims to constitute the grade of understanding regarding adaptation, for example through the development of common indicators.

However, there is a gap with respect to the implementation of climate adaptation initiatives since there is not enough clarity regarding how to approach the implementation. In the present, there are different points of view leading the academic field regarding climate adaptation implementation. Approaches goes from Adaptation Tracking, policy instruments, policy mixes, mainstreaming to a mismatch between all of them. But what is more concerning is that this is not a specific condition for climate policies, rather it comes from its origins, where currently the literature emphasizes the lack of general frameworks with respect to the implementation of public policies in general (Khan 2016). This complexity added to the already present challenges that adaptation has per se, increase the uncertainty regarding the implementation of climate adaptation actions.

2.3.1 Factors that influence the implementation phase

As seen on the previous section, the policy processes, as well as the implementation sub-processes, have several components. Within the implementation process, there are three interconnected elements that interact and feed into each other: factors, strategies, and evaluation (Moullin, 2015). Any of these elements can face challenges that result in affecting a successful implementation. In this study we will focus on implementation **factors**, which

have been studied previously by different academic bodies which can be define as the elements that directly and indirectly influence, by boosting or constraining, the implementation of climate adaptation actions (Kahn, 2016; Mogelgaard et al., 2018; Runhaar, 2018, Uittenbroek 2016; Di Guilio et al., 2018, Ryan, 2015; Biesbroek et al. 2009, Biesbroek et al. 2011, Eisenack & Moser, 2014).

The first thing that draws attention to the factors that affect the implementation of adaptation actions is that they cover a wide range of elements. In turn, this makes difficult to spot which elements predominate over others. Literature adds to this complexity the fact that barriers and enablers change over time. Furthermore, the implementation of actions is not something that is achieved overnight, but is a long process that sometimes takes years, so many present and future decisions are affected by past decisions and investments (Eisenack & Moser, 2014).

Although policies factors are generally repeated (resources, organizational capacity, political influence, among others) there are certain frameworks that have tried to narrow down the factors, and work on these elements from a local point of view (Ryan, 2015, Giulio et al., 2019), considering only the influencing factors at the level of implementation (Runhaar, 2018).

On the one hand, according to Ryan (2015), there are local capacity factors that if not present, they incapacitate municipalities from implementing climate policies. But it also emphasizes that, although these factors are essential for implementation, they are not sufficient, because there are other factors that can prevent or tardy the implementation of an action. Local framing and political factors are two key elements that influence the capacity of a local government, by having the power of impede or boost policies and actors, which has a direct impact on the capacity of local governments, and therefore on the implementation of climate adaptation initiatives.

On the other hand, the study from Runhaar (2018), developed an analytical framework based on a literature review to look for the main factors that affected the implementation of climate adaptation. In the study, the effectiveness of an implementation was measured in terms of policy outputs and outcomes and the reports analyzed show the frequency of factors and if they boost or constrain the implementation of adaptative actions. There are some factors that are much more frequent that other, as framing, financial resources, cooperation with private sector, and political commitment.

Di Giulio et al. (2019) also studied factors that act as barriers or enablers in climate change adaptation. Its study followed a literature review referring several times to the work of Ryan and Runhaar, and then developed a framework to understand the main elements that help understand the existing gap between will and action of climate adaptation policies (resources, organizational and political factors, among others).

2.3.2 Framing factor

Adaptation to climate change is a broad concept that can be interpreted by many people in different forms. This leads to the development of different ways of conceptualizing the term, meaning that there are different points of view for adaptation to climate change. This generates an impact on policies, as well as on the moment these adaptation policies are implemented, since these different approaches affect how a policy will be developed and the outputs that are expected in the implementation. The body of literature stressed in the following types of framings (*Table 2*).

Table 2 Adapted from Dupuis & Knoepfel (2013) & Fünfgeld (2013)

Adaptation Framing types	Approaches
Climate change -based	Anthropogenic climate change, which aim is to adapt to the impacts of the climate change derived from the activity of man
Variability-based	Climate variability seen as a problem in the present and future, independent if hazards are produced by man of nature
Vulnerability-based	Impact causes by exposure of the system with sensitivity responsiveness and adaptive capacity to recover
Hazards-based	Climate change as the precursor of perturbations, stress, and threats of a system
Risk-based	Explicitly embraces on uncertainty and risk notions
Resilience-based	Response of systems, humans, and nature, to cope with external hazards and disturbances

A study developed by Dupuis & Knoepfel (2013) analyzes the different adaptation framing of two cities in Switzerland and India, showing that to implement adaptation measures it is necessary to consider beyond the local capacities that a municipality has, going further and see how policies are being framed. Vulnerability-based adaptation turned out to be the most tractable framing adaptation, by better attending local worries and being more likely to receive support from local actors.

According to Fünfgeld et al. (2012), adaptation framing can happen at three different levels, though not exclusively. The first level is the meta-level, where adaptation can be identified in values and its culturally insert in public policies. The second level is the conceptual, where local authorities have frame adaptation through several frameworks, such as risk management and climate change adaptation plans. The last level is the operational one, which translate the values and documents into concrete projects, reports, and documents. Therefore, having adaptation framing in all levels facilitates the implementation of a policy, since local governments may have different actors and instruments involved to support initiatives under a common purpose. Romsdhal (2020, p.147) define framing as an "opened public dialogue that helps bridging political divisions over policy actions at local scales, to complement national and international efforts. Opening up public dialogue may improve engagement to manage climate change issues through local governance".

2.3.3 Political factors

Political factors play an important role at local level since they can influence in government capacities. That is why many territories seek support in international and/or private networks to attract resources and capabilities to face climate change. Also, the role of powerful actors, like businesses, can interfere or boost in the implementation of climate action (Di Gulio, 2019; Ryan, 2015; Eisenack & Moser, 2014).

Di Gulio (2019) in his study of the cities of Brazil, identifies political will and commitment levels as facilitators or hampers of climate adaptation implementation. When politicians are more willing to collaborate and see the issue of climate change and the need for adaptation as a priority, co-benefits are created that affect other areas such as health, education, transportation, etc. It is important not to see climate change as a competitor and put it aside, but rather to see it as an ally to drive policies. Lankao et al. (2013) in the study of Mexico City and Santiago de Chile, highlighted that in both cities economic ideologies still predominate, making it difficult to cover sustainability and the environment. However, in both cities there is political leadership and participation in global nets that seek to integrate climate change into political programs.

Political cooperation is another aspect that refers to the availability of programmes, resources, and information among different government levels, where authorities can facilitate, support, and expand different policies among sectors to acquired goals and boost projects (Stead & Meijers, 2009).

Runhaar et al. (2017) study focuses on analyzing the factors that influence the implementation of adaptation initiatives. One of the categories it emphasizes is political factors, such as interests that are aligned or in conflict with adaptation goals, the level of support that adaptation measures have, as well as the stability of the policy. All of them having direct repercussions over the capacity of a local government to articulate its actions and priorities.

2.3.4 Local government capacity

Local government capacity is one of the factors that attract more attention academically speaking, because several studies show the capacities of a government and/or organization as the major factor when considering adaptation measures. Especially at municipalities where mostly of the initiatives that are being implemented are taking place at this governance level.

The list of factors that enable implementation under this component is broad. Many authors (Di Gulio, 2018; Ryan, 2015, Eisenack & Moser, 2014, Lankao et al., 2013, Runhaar, 2017) name resources as one of the main factors under governance capacity that affects the implementation of actions. Financial resources directly affect the purchasing power and independence that a local government has for developing and implementing adaptation initiatives. The way in which local governments are financed, for example through taxes, is of utmost relevance when analyzing the implementation of adaptation policies, since the collection and percentages vary according to the country's context and its laws, at the same time making a difference internally at the communal level, depending on the characteristics of that territory (number and inhabitants, if it is a municipality with many companies, the level of resources of its inhabitants, etc.). Staff resources dedicated exclusively to climate change issues and how to face vulnerabilities also make a difference when it comes to implementing climate actions. Developing capacities internally through training and having exclusive staff dedicated to climate change issues facilitate the response capacity. Further, access to data, information and guidelines are also consider important resource factors to implement climate policies.

Another local governance capacity that affects action's implementations are the organizational factors. Participation in networks it is a way for local governments to expand their tools and to have greater external support if they do not have sufficient internal capacities to be able to promote climate issues. Further, organizational structure also plays a role because many climate change initiatives are being covered by environmental departments, which in turn have other tasks at hand, making it difficult to prioritize the implementation of specific climate issues over other actions, normally defined by statute defined in the description of the functions of

the departments (Runhaar, 2018). Supportive legislation or regulations are other additional characteristics that influence and facilitate the implementation of adaptation initiatives, since having legal support makes your actions protected under legal regulations.

2.2 Conceptual framework

The objective of this study is to analyse the factors that enable the implementation of adaptation actions in the Metropolitan Region of Santiago, Chile. Furthermore, the study also investigates the current state that municipalities have in relation to climate adaptation.

The factors chosen are based on academic literature and mixes of three frameworks, the Ryan (2015), Runhaar (2018) and Di Giulio (2019) assessment. The selection was basically made because the appraisals are directly focused on the implementation stage of climate actions, making a more pertinent and accurate evaluation.

Regarding the implementation of climate adaptation initiatives, the operationalization took some of the elements from the framework of Lesnikowski et al., (2013): How are we adapting to climate change? A global assessment. Mitigation and Adaptation Strategies for Global Change.

The combination of concepts, variables and indicators can be identified in the following conceptual framework:

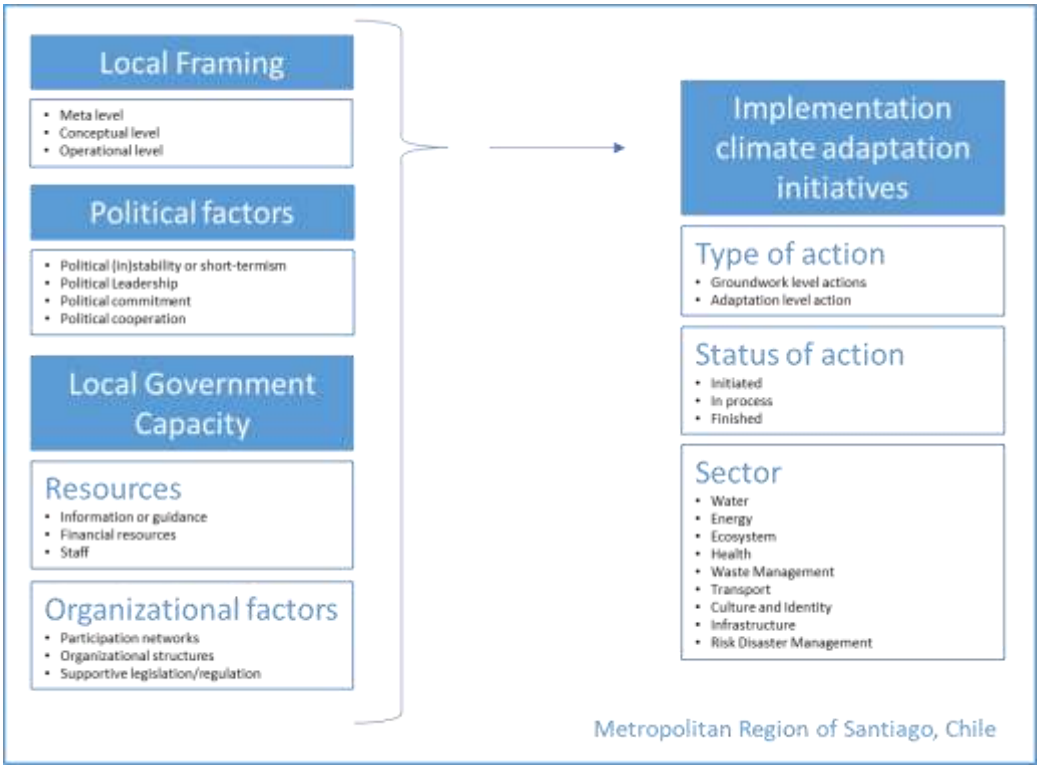

Figure 3: Conceptual Framework

Chapter 3: Research Design and Methods

3.1 Research strategy

The research strategy for achieving the previously defined objective consisted of three different analyses. The first analysis involved a desk research based on having a general and wide analysis of primary data, mainly policies and its instruments, to see the current adaptive climate situation and actions in Chilean Metropolitan Municipalities. It is a suitable method due to the large number of samples and variables, so prioritization of time and cost is required to get the correct information in a constraint period of time. Also, this method has proven effective when working and analyzing large number of units, for the generalization of conclusions.

To complement this information a survey was conducted with the purpose to go in depth by exploring and investigating the factors and relations of municipalities that have successfully implemented adaptation initiatives within its context.

With all this information a Qualitative Comparative Analysis (QCA) was performed. This approach enables to investigate cases and factors that possibly cause an outcome assessing equifinality, meaning that more than one combination of factors could lead to the same outcome. Being adaptation a complex concept and the factors that might lead to the outcome also, this way of evaluation allows to see why in some municipalities the presence of a condition lead to the same outcome as in other cases the absence of that condition. Within this, three short case studies were analyzed to enhance reliability and validity by a combining strategy. It also enables to put the main characteristics into practice within its context, get deeper understanding of insights while developing an adaptive implementation analysis from a south globe perspective.

3.2 Data collection method

The construction of the variables in this study was through a primary and secondary data collection.

3.2.1 Primary Data Collection

A questionnaire was sent online (*Annex 1 : Questionnaire for* Municipalities) through the transparency website of the Chilean government. Entities count on 20 business days from the first business day after receiving the request to reply. The questionnaire consisted of 17 open, closed, and multiple-choice questions and were divided into two sections:
1. Local government capacity: questions designed to gather information on the local municipal capacity to face the challenges of climate change with respect to resources and organizational factors.
2. Implementation of climate adaptation initiatives: questions in this section were designed to collect information on the implementation of climate adaptation initiatives by sector, with the aim of analyzing how actions are being prioritized and what factors influence their implementation.

The survey was managed in Spanish, their native language and it was requested that the public worker that answer the survey was ideally a functionary who is aware of the implementation of climate adaptation initiatives or has mastery in matters of sustainability and climate change

3.2.2 Secondary Data Collection

A total of 77 documents were analyzed and classify to see the current state of municipalities regarding climate adaptation, the list of documents review by municipality can be seen in *Table 3* with the details.

The main documents reviewed were:

1. PLADECO's: This document is an instrument of strategic planning and municipal management that aims to be a response to the social demands and needs of the community in social, economic, cultural and any area related to the interest of the commune and its population. The PLADECO defines the projects that the commune wants to undertake and the proposals that arise from the community are collected as well as investment initiatives that are prioritized according to the most "felt" deficiencies and needs of the inhabitants of each of the sectors of the territory. Of the 52 municipalities, only one document was not found. For analysis, the latest PLADECO found in the government's transparency portal or on the official website of the municipality was considered.

2. CAPL's[1]: The CAPL are instruments that, to be developed, the municipalities had to go through a training process in the so-called "Climate Change Academies". In general terms, these academies seek to contribute to the development and improvement of skills in municipal technical teams, which allow them to generate their own proposals and be the managers of changes. The main tools resulting from this process are the Local Climate Change Plans, which collect the diagnosis on the capacities and vulnerabilities of the communes to face climate challenges, and set the objectives, lines of action and measures aimed at the adaptation and mitigation of associated damages, on a five-year horizon. The total 15 number of MRS plans found on the official pages of the RedMuniCC were analyzed.

3. LES'S[2]: These reports were prepared in the context of the Energy Commune program promoted by the Sustainable Development Division of the Ministry of Energy. The main objective of these plans is to be a tool to promote Energy Efficiency (EE), Non-Conventional Renewable Energies and the reduction of CO2 emissions in the commune. The 11 documents found on the official pages of the RedMuniCC were analyzed.

[1] [2] CAPL and LES are articulated by RedMuniCC the climate change municipal network, which work in collaboration with different organizations at national and international level i.e., in case of LAS RedMunCC worked with the Ministry of Energy and in terms of CAPL, the "Climate Change Academies" and other trainings are in collaboration with Euroclima, a program funded by the European Union.

Table 3: List of documents review by municipality

Climate Change Adaptation Plan (CCAP)		Local energy strategy (LES)		Communicational climate change strategy (CCCS)	
Santiago	☑	Conchalí	☑	La Reina	☑
Independencia	☑	Independencia	☑	Macul	☑
La Pintana	☑	La Pintana	☑	Maipú	☑
La Reina	☑	Peñalolén	☑	Quilicura	☑
Macul	☑	Providencia	☑	Renca	☑
Maipú	☑	Quilicura	☑	Vitacura	☑
Peñalolén	☑	Recoleta	☑	Calera De Tango	☑
Providencia	☑	Renca	☑	Talagante	☑
Quilicura	☑	Vitacura	☑		
Renca	☑	Colina	☑		
Vitacura	☑	Calera De Tango	☑		
Colina	☑				
Lampa	☑				
Calera De Tango	☑				
Talagante	☑				

From the documents analyzed, 2284 programs, projects, initiatives were classified into different sectors, type of initiative (ground level or adaptation level) and current state of the action was provided (initiated, in process, finish), for details see Table 4: Operationalization - Independent and dependent variables and indicators.

3.3 Sample size

The data sample was established based on the number of municipalities that responded to the survey. From the 52 local governments, 41 positive responses were received, 1 denial, 3 prorogues, a blank survey and 6 no answer were recorded.

Figure 4 shows the information of the Municipalities that participated in the research, for more details see *Annex 2: Sample Municipalities of the MRS.*

Figure 4: Map of responses Municipalities MRS

3.4 Data collection analysis

3.4.1 First approach – Excel data base

The data of the surveys were received under PDF or Word documents. In an excel data base each answer was coded and then a matrix was created that linked every answer to the required variable. More than one time the data should be complemented with public records.
In this process four variables were eliminated of the model:

1. Meta level: This variable measure if adaptation is inserted in national public policies. After the review of documents, it was observed that adaptation was indeed inserted at the national level and there were guidelines for local governments. In that sense, this variable would have been present for all municipalities because of its constant behave. Therefore, it could be omitted of the analysis since it does not contribute or differ in each case, rather its presence always contributes to the same direction, not generating significant impacts.
2. Operational level: This variable is not within the independent variables to be analyzed, because the operational level is finally the implementation of programs, measures, and initiatives, which in this case is the dependent variable that is being analyze.
3. Political short-termism: This variable also takes a constant value, since all the municipalities of the RMS are under the same regulation in which a mayoral period lasts 4 years. In the event of a reelection, this was considered within the Political Stability variable.

4. Participation in international networks was already included and coded under the variable “Climate Change Networks”.

The analysis of Meta level and Political short-termism can be found in *Annex 3: Variables excluded from the model*.
The analysis of the Operational level can be found in *section 4.1*.

3.4.2 Second approach – QCA Model

According to Schneider & Wagemann (2012), the development of an QCA provides an added value in the nowadays typical correlation approaches by the study of set-theoretic relationships between a social phenomenon. Set-theoretic recognized the existence of equifinality, which means that alternative factors can end producing the same outcome. Further, this method, combines qualitative and quantitative approaches, allowing a twofold analysis of case studies by assessing them and learning the complexity of each case. The implementation of adaptation actions is a complex topic and the factors involved also, thus a QCA process was considered adequate for this research.

The comparative analysis employs a Software called fsQCA which uses an algorithm called Quine-McCluskey to find simple combinations of sufficient and necessary conditions that lead to an outcome (Schneider & Wagemann, 2012). But firstly, the data must go through a calibration process, whereby memberships values are assign considering theoretical and empirical evidence. In the calibration procedure the collected data was transformed into sets. Crisp and fuzzy variables were chosen depending on the type of information that was provided by each variable in the data basis, in *Annex 5*: QCA Calibration process the complete information and reasoning behind the process is explained in detail. The data after calibration was process in the software fsQCA 3.0 in form of a truth table algorithm. This table computes all the possible combinations that may occurs depending on the number of conditions of the model, in this case 10 variables were chosen; thus, the model provide 2^{10} rows, 10 representing the outcome predictors and each row represent all conceivable combination. The frequency can also be observed in this table, indicating the number of cases for each possible combination (Figure 5). There are rows with 0 cases which can be interpreted as none of the cases are explained by one of those combinations. The truth table also sort by frequency and consistency. In this research a frequency threshold of 1 was configurated given the small size of the sample (41 cases). The consistency score was established in 0.8 which is an acceptable value according to literature (Pappas & Woodside, 2021; Ragin, 2017; Schneider & Wagemann, 2012).

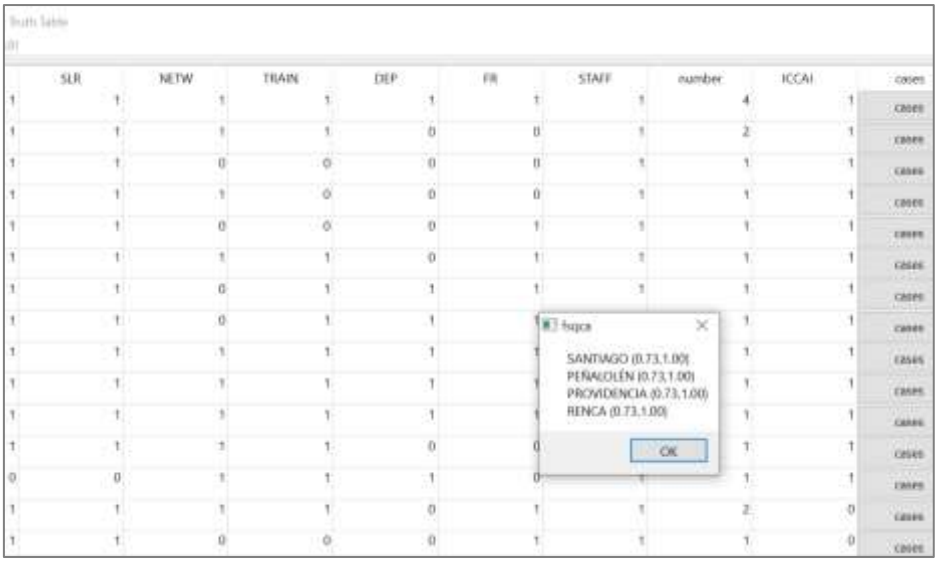

Figure 5: Truth table in fsQCA

3.4.3 Third approach: Case Studies

QCA is used to interpret and analyze case studies. This research started with several case studies and after applying fsQCA different sets that reach the same outcome were found. Each one of this sets is composed of different cases, which will allow to generalize certain factors that apply to more than one case study. There are several qualitative differences when choosing within-case analysis to be able to study in an extensive and depth manner a complex phenomenon. The idea to have multiple case-study research method is to justify that the implementation of adaptation initiatives doesn't work out in the same manner and the reach of the outcome can come from different mixtures of factors. Therefore, it is interesting to choose different municipalities with different backgrounds and capabilities to be able to contrast and compare these cases to see what similarities and differences occur at factor levels and how these affect the implementation of actions. Schneider & Wagemann (2012) provided graphically the different types of cases within a solution (*Figure 6*). The case studies will focus and based on area number 1 "Typical case studies" which are sufficient, since they are located above the diagonal and have empirically data that justify the outcome Y and the specific set selected (X). Further, after the QCA performance there are different strategies for selecting case studies. In this thesis, the case selection principles were: "1. principle of diverse case selection: Choose at least one case for each term of the solution; 2. Principle of unique membership: Choose cases that are covered by just one term" (Schneider & Wagemann, pp.311, 2012) Based on the results of QCA, three municipalities were chosen.

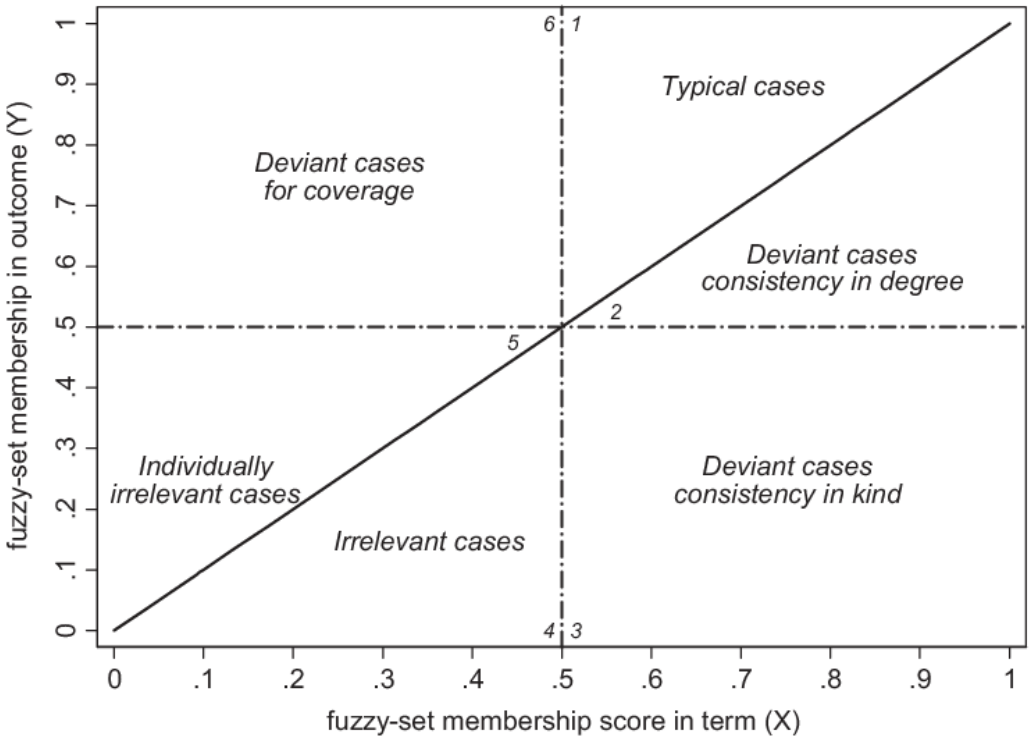

Figure 6: XY plot with two-by-two table and types of cases – Schneider &Wagemann pp.308 (2012)

3.4.3.1 List of Case Studies

1. María Pinto: Response to the p*rinciple of diverse case selection.* This municipality is mainly rural and lacks financial resources, however, its commitment is what has allowed prioritizing climate adaptation, opening the doors to receive subsidies, which are seen as an asset to generate later internal impact. Among the adaptation initiatives, they conducted multiple trainings and restored urban forest ecologically through citizen participation and the recognition and work with wetlands.
2. Lo Barnechea: Response to the *principle of unique membership* and it is characterized by being one of the two municipalities in the RMS to have a specific Directorate for sustainability. This driver is the one that has facilitated the implementation of climate adaptation measures by easing the articulation of a series of factors ensuring efficient execution and effective administration of resources and projects.
3. Providenica: This local government has developed a climate change adaptation plan. A crucial factor with a high impact for the implementation of measures, since it facilitates, articulates, and transversally promotes its commitment among different actors. Its response to the *principle of unique membership*.

3.5 Main challenges and limitations

- Limitation regarding data availability and last updates documents available
- Struggle in conducting the survey due:
    - the recent change of Mayor mandate and social-political context of Chile, plus the influence of the pandemic in their answers
    - the official and formal system to get information of public entities has a response of 20 business days, with the option of an prorogue for additional 10 business days which can slow things down

- Difficulties in the reliability due the context-specific of the study

3.6 Operationalization

The research will be conducted according to the concepts of Adaptation factors and the Implementation of adaptation initiatives.

In this study adaptation factors are the elements that enable or restrict the implementation of adaptation initiatives. The concept is divided into three main variables: **1. Local Framing**, **2. Political factors** and **3. Local Governance capacity**, which directly influence in the implementation of adaptation initiatives. The variables are defined as follows:

Local Framing is an "open up public dialogue and help bridge political divisions over policy actions at local scales, to complement national and international efforts. Opening up public dialogue may improve engagement to manage climate change issues through local governance" (Romsdhal, 2020, p.147).
Political factors comprehend the social and political context of a determinant territory. Elements as political commitment, leadership and (in) stability are crucial factors that can support or restrict local capacity elements.

Local governance capacity is an element that consider resources as financial, staff and knowledge development which are key in the implementation of adaptation initiatives (Ryan, 2015).

Implementation of adaptation initiatives is defined as: a project, regulation, information, or program that is translate by the municipality into a concrete action. This variable has three sub variables:

Table 4 show the operationalization.

Table 4: Operationalization - Independent and dependent variables and indicators

Concept	Independent variables	Sub-variable	Indicator
Factors	**1. Local framing**	**1.1 Meta level**	- Adaptation is inserted in national public policies (Yes/No)
		1.2 Conceptual level	- Local authorities developed climate change adaptation plans (Yes/No)
		1.3 Operational level	-Concrete climate adaptation projects, reports, and documents (Number)
	2. Local Governance capacity	**2.1 Resources**	- Information or guidance (number of trainings related to climate change) - Financial resources ($ of the municipality) - Staff (number of people working directly on climate adaptation)
		2.3 Organizational factors	- Organizational structures (Specific department for sustainability or climate change Yes/No)

			- Supportive legislation/regulation (Municipality has a specific climate change policy Yes/No) - Participation networks (Participation on municipal associations regarding climate change Yes/No)
	3. Political factors		- Political (in)stability or short-termism (change of mayor, political stance Yes/No) - Political cooperation (specific subsidies, programmes for climate change issues Yes/No) - Political leadership (participation in transnational networks Yes/No) - Political commitment (Development of national strategies regarding climate change adaptation Yes/No)

Concept	**Dependent Variable**	**Sub-variable**	**Indicator**
Implementation of climate adaptation initiatives	**1. Type of adaptation initiative (Mutually exclusive)**		- Groundwork level action (Impact and vulnerability assessment, adaptation research, conceptual tools, climate change scenarios, stakeholder's networking) - Adaptation level actions (Organizational development, regulation, infrastructure/technology/innovation, public awareness and outreach, surveillance and monitoring, resource transfers and financial support, performance reviews of adaptation progress)
	2. Sector (Not mutually exclusive)		- Critical Infrastructure - Ecosystem - Health - Transport and mobility - Culture and identity - Disaster risk management - Water - Energy Waste management
	3. Status of action (Mutually exclusive)		- Initiated - In process - Finished

3.7 Ethics, Reliability and Validity

3.7.1 Ethics

All municipal information used for this study is public under the Chilean Transparency Law n°20.285, which states that all financial information of public institutions must be of public access to all the citizens, for the generation of new spaces for participation and improving the accountability of public management. There is no personal data, only public data, meaning there is no risk of making any harm to participants, confidentiality, anonymity, and informed consents within this study.

3.7.2 Reliability and validity

To increase the levels of reliability and validity, this research used data triangulation. Regarding data sources and operationalization, three different methods were taking into consideration: 1. official government documents; 2. specific questionnaire, and 3. earlier studies. Further, the analysis was performed through a QCA model, in which qualitative and quantitate data was analyzed within three case studies to get in depth information and insights.

Regarding reliability, the accuracy and consistency of the study must be analyzed to evaluate that the results are systematic and representative (Thiel, 2014). First, about accuracy, the instruments used in this study were a combination of desk research and questionnaire, with the purpose of generating variables that can be captured in a correct and precise manner. Desk research was performed over official government documents, which were complemented with in depth information from the surveys. Second, consistency look for the repeatability of the study, which means that under similar circumstances a similar outcome can be achieved (Thiel, 2014). This study developed a QCA model, which works with the variables created from the research methods exposed before in a qualitative and quantitative manner. This method provides solutions which are consistent, whereby is expected that another research using similar data can expect comparable results by processing the data in the same manner. Thus, the steps undertaken and the systematic approach of this study are explained in detail for potential review and replication.

In terms of validity, it can be distinguished between two types: internal and external. Internal validity refers to the operationalization of the study and the relationship between dependent and independent variables (Thiel, 2014). This study was constructed based on previous literature findings and research, in which some theories behind certain factors were confirmed, while other findings were discover that built on academic knowledge of climate adaptation implementation. Nevertheless, internal validity can be only guaranteed to a certain extent because there might be other variables that influence in the implementation of climate adaptation initiatives that were not evaluated in this study. External validity denotes the extent to which a study can be generalized (Thiel, 2014). In the case of this research, external validity is low, since findings are bound to the specific context of the Metropolitan area of Santiago, Chile.

Chapter 4: Research Findings

This chapter presents the analysis of the data collected and its main findings to answer the research question: Which factors enable the implementation of climate change adaptation initiatives in Chilean Metropolitan Municipalities?

As explained in the third chapter, primary data was collected through questionnaires sent to all Municipality in the RMS, while secondary data was collected from official municipal website as the Transparency portal of the Chilean public sector.

In chapter 4.1, the current state of MRS Municipalities regarding implementation of climate adaptation initiatives was analyzed through twofold study. First, a series of documents were reviewed to identify and classify initiatives according to the type of adaption initiative, the sector in which those actions belong, and the status of the action (initiated, in process or finalized). Second, the perception of municipalities was evaluated using the questionnaire in a systematical way, to see which enablers were prioritized and understand why certain factors could be seen as drivers.

Chapter 4.2 presents the QCA analysis in which the results of the model were examined quantitatively and then qualitatively through case studies. Being able to analyze cases in quantitative and qualitative aspect ensures a more complete and robust analysis, which is QCA main objective (Schneider & Wagemann, 2012).

Finally, chapter 4.3 presents main findings where section 4.1 and 4.2 are compared and complemented. This allowed the information to be analyzed as a whole, ensuring triangulation and being able to focus on the factors that are more significant for the municipalities of the RMS in terms of implementation.

4.1 Analysis - Current state of municipalities regarding CCA

To evaluate the implementation of adaptation initiatives, 77 documents were evaluated which contained information on programs, projects and initiatives related to adaptation to climate change. The thematic areas and related actions were classified according to the RedMunicc (*Annex* 4: Sector classification under RedMuniCC guidelines). After, through the survey, the main factors were classified under driver or constrain, to see which the perception of RMS was respecting the implementation of actions.

4.1.1 Type of Action

From the 1755 initiatives 60% were categorized under Groundwork level activities such as plans, policies recommendations and impacts/vulnerability assessment. The left 40% were classified under Adaptative level actions, which are tangible initiatives as infrastructure improvement, new constructions, public awareness and outreach, organizational development, and monitoring.

Table 5: Type of Actions by Province MRS

Province/Type of action	RedMuniCC	Groundlevel actions	Adaptation actions	Total
Chacabuco	67%	38%	62%	100%
Cordillera	0%	79%	21%	100%
Maipo	25%	43%	57%	100%
Melipilla	0%	66%	34%	100%

Santiago	34%	54%	46%	100%
Talagante	20%	69%	31%	100%

When analyzing the type of actions by province, it can be seen that the provinces with zero or less percentage participating in RedMuniCC are the ones with the highest concentration of initiatives at the Groundwork level. These results bring a baseline to understand where adaptation is occurring and the nature of the actions that are being developed. For example, in Chacabuco, of its three municipalities, two belong to the RedMuniCC network, which means that those local governments have developed a CAPL and/or LES, indicating an increase in tangible implemented actions. This is interesting since it shows a first difference between the municipalities that have developed adaptation plans and/or energy strategies versus those that have not, where the actions go beyond the mere organization and recommendation of initiatives.

4.1.2 Sector

The sectors with greatest predominance are Energy, Ecosystem, Culture & Identity (*Figure 7*). The energy prevalence can be explained due the LES's plans where a large number of concrete actions were specified that increased this number. The municipalities that count with an energy strategy, have in average more than 34 additional projects than the local territories who doesn't count with such a plan.

In respect with ecosystem the percentage is high especially because of project related to arborization in passages and avenues, construction of green areas such as parks and land registry of urban trees.

Regarding Culture & Identity, this sector, focuses on the promotion of a series of groundwork level initiatives such as the promotion of citizens participation and the participation of indigenous population in territorial planning. The RMS is the region with greatest percentage of indigenous population, having a 30% of the population of the country, therefore there are a lot of municipalities that have developed specific initiatives in their PLADECO's and CAPL's with respect to the improvement in the involvement of this population in the different territory processes and projects.

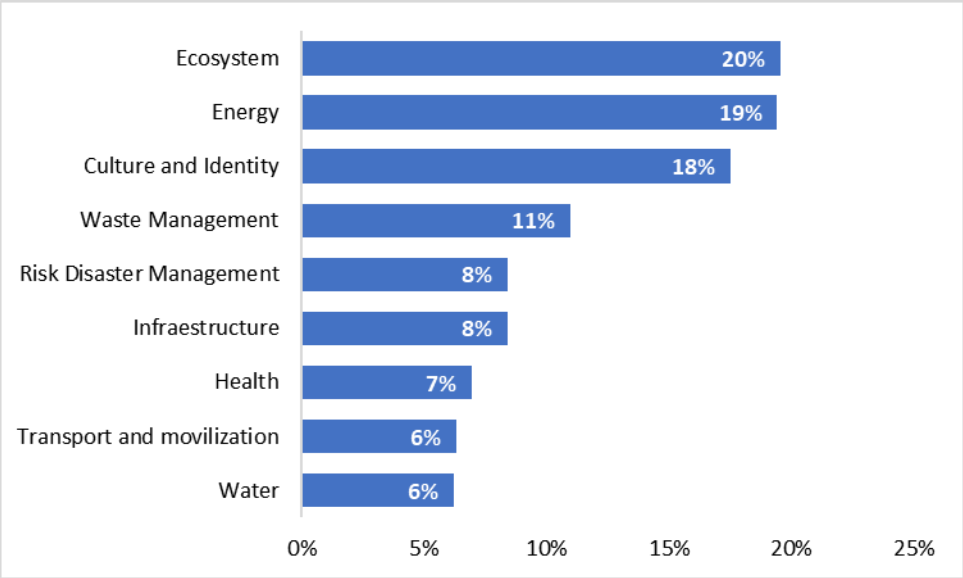

Figure 7: Implementation of adaptation initiatives by sector

Table 6: Implementation of adaptation initiatives by sector and province

Sector/Province	Chacabuco	Cordillera	Maipo	Melipilla	Santiago	Talagante
Water	23%	14%	6%	10%	3%	11%
Energy	26%	5%	29%	4%	23%	4%
Ecosystem	12%	14%	17%	27%	18%	29%
Health	4%	15%	6%	10%	6%	12%
Waste Management	7%	12%	10%	8%	12%	10%
Transport and mobilization	3%	3%	3%	5%	7%	6%
Culture and Identity	11%	28%	24%	25%	16%	22%
Infrastructure	7%	4%	2%	7%	10%	4%
Risk Disaster Management	6%	5%	3%	4%	5%	3%
Total	100%	100%	100%	100%	100%	100%

Looking the sectors by province, the territories that have LES (Chacabuco, Maipo, Santiago) have a high number of initiatives focused on energy, which is to be expected.

In the case of Chacabuco, it is seen that beside from energy, the other sector that predominates is water. This issue is essential for this province, since this territory is characterized by a high percentage of population that lives in rural conditions (20.7%) that depends on agricultural activity. Two out of three municipalities of this province have developed a CAPL, which helped identify the vulnerability that the population faced towards water scarcity, thus, part of the CAPL is to develop the climate profile of the territory, where the risk and vulnerabilities are recognized. In this case, it can be easily appreciated the number of initiatives that are linked to the water sector which was prevailed.

With respect to the other provinces, it is not possible to see a pattern as marked as that of Chacabuco, which could be given because the other provinces do not have a great adherence to RedMuniCC. This could imply that those territories haven't identified their vulnerabilities and risks yet, so there is no clarity of where to focus or what to prioritize.

By its side, the province of Santiago is the one that has developed the greatest number of adaptation plans (11) but it represents only 34% of the total number of municipalities in the province. If this province is analyzed, only considering the municipalities that have developed adaptation plans (*Table 7*), it can be seen that Waste Management becomes one of the key issues where municipalities are working beside the other relevant topics (energy, ecosystem and culture & identity). Of the RMS, this province is the one with the largest number of inhabitants (59%), so the generation of garbage, its treatment and disposal is clearly a relevant issue on the agenda of these municipalities.

Broadly, the previous shows that developing a CAPL and/or LAS, allows to observe more precisely what the municipalities are focusing on and what is being prioritized. This accounts for a first factor that seems to be crucial in the implementation of climate adaptation measures, which is the creation of plans as drivers of actions.

Table 7: Climate plans: Province of Santiago, initiatives per sector

Sector	% Initiatives per sector
Energy	33%
Waste Management	13%
Ecosystem	12%
Culture and Identity	11%
Infrastructure	9%
Transport and mobilization	7%
Risk Disaster Management	5%
Health	4%
Education	3%
Water	3%

4.1.3 Status of projects

Only 24% of the actions categorized, provided information whether an initiative was initiated, in process or finished, which is equivalent to 549 actions.

From these initiatives it is known with certainty that only 22% (*Table 8*) have been finished.

Table 8: Status of adaptation initiatives

Initiated	In process	Finished	Total
125	302	122	549
23%	55%	22%	100%

LAS's documents, have only one Gantt chart that is sometimes specified for years and other times for short, medium, and long terms. About PLADECO it is even more critical since of the 51[3] documents analyzed, only 3 municipalities have a monitoring, control, and public record of the status of their project portfolio (Lo Barnechea, La Florida and Santiago). The other municipalities have a Gantt charter, but there is no specification of the current status of these projects, but it is expected that they should have a registry, since PLADECOS last a minimum of 4 years, and there are municipalities that even have these documents developed with a validity of 10 years.

The municipalities that developed CAPL represented a 68% of the actions that could be categorized under *Status of action.* This is a high percentage considering that they represented a 29% of the 52 local governments of the RMS. However, it is concerning that 76% of the actions does not present any kind of reportability, which coincides with the study of Araos (2016) & Berrang-Ford et al., (2010), which also shares a high percentage of cities at a global level that do not report their adaptive activity.

[3] Peñaflor's PLADECO was not found

4.1.4 Perception of main drivers

In the survey sent to Municipalities, the main enablers were asked to evaluate how the perception of this entities regarding the implementation of climate adaptation was. From the 52 Municipalities, 41 positive responses were received, which represent a 79%. The summary can be seen in *Table 10*.

Development of Climate Adaptation Plan (CAPL)

On the one hand, this variable was considered as enabler by a 97% of the sample. Indeed, these plans make a difference, starting from the fact that the municipalities that have them already developed their climate profile, so they have more information and lines of action as concrete projects to carry out regarding climate change adaptation. Further, in the process they also received trainings and workshops related to climate change which helps before and after the development of the plan and finally transversal elements are defined such as the communicational strategy of the plan, the joint raising of funds for implementation and the follow-up of compliance (Adapt Chile, 2017). The previous can be confirmed with secondary data analysis from section *4.2.1 Evaluation of documents*, where 68% of the reportability of adaptation action implemented is explained by the municipalities that have CAPL.

Political stability (STAB)

Political stability was considered by 78% of the municipalities as a driver. Municipalities that see it as a barrier could be because of the perception that they have regarding the social-political crisis that Chile is facing nowadays which leads to a complex scenario of uncertainties about what can happen in the future, considering last May Major's elections where new political forces won and the presidential primary elections in July also brought surprising results, leaving out the usual political groups. Even though, the data collected shows that almost every municipality of the RMS has been stable during the last 12 years. Only two local governments have suffered a change of government, but it was not an impediment for the implementation of climate actions. Taking this, it can be realized that practically all municipalities (95%) have remained politically stable in recent years and even those that have not, have been able to implement adaptive actions, which coincides with the literature, which emphasizes that climate change is an issue that has not yet been politicized and therefore remains stable (Ryan, 2015; Ryan, 2012).

Political cooperation through subsidies and programs (COOP)

This variable is seen as an enabler by an 95% of the MRS. Nevertheless, in practice 28% of the local governments have received subsidies and programs for the implementation of climate adaptation initiatives. From this percentage, there are public alliance funds and public-private funds, from national and international origin. The subsidies and programs are vast and diverse. ADAPT Chile, The Environmental Ministry and the Sustainability and Energy Agency are the most repeated organizations among the participants.

Political Commitment (COMM)

94% of the respondents considers this variable as a driver. Focusing on their answers on whether they would consider this issue within municipal priorities, 57% of local governments consider it within the 3 strategic pillars to prioritize, while 80% would consider it within the

first 5 issues. Only 2 municipalities would not prioritize it. This result is interesting, because although it is an issue that is considered by almost all the municipalities in the sample as a driver, prioritization prevails within the first 5 strategic pillars, so although it is something important but not enough to be in the top 3.

Supportive legislation/regulation (SLR)

Respect SLR, a 68% of municipalities considered it as a driver. What happens in reality is that 73% of Municipalities does not have a climate change policy, and those that have it, are all concentrated in the province of Santiago. Nevertheless, 67% mention that climate change adaptation is integrated into other policies of the organization. For example, there are some municipalities that have developed an Environmental Policy with climate change actions lines (Lo Barnechea, Recoleta, Santiago, Peñalolén, Huechuraba, María Pinto, among others). About the fact of being aligned with the National Climate Change Strategy, 59% of local governments mentioned to support it i.e. Municipality San Miguel stated in the survey "Considering that the Chilean Ministry of Agriculture and CONAF have led the development of the National Strategy for Climate Change and Vegetation Resources 2017-2025 (ENCCRV), and that for the fulfillment of the commitments provided (…) during the last 3 years the Department of Green Areas and Urban Trees has been awarded 3 reforestation projects with native specimens for urban areas in San Miguel, promoting the strengthening of native trees within the set of plant specimens present at the communal level. Of these tasks, more than 90% have survived with optimal development, providing excellent environmental services to both neighbors and the environment.".

Climate Change Networks (NETW)

A 95% of local governments perceived this factor as a driver. Almost half of municipalities (48%) participate in climate change or sustainability associations being RedMuniCC the one with greater adherence (*Figure 8*) with a 71% of municipalities participating. Mostly networks are bounded in Chile, but there is also international networking, for example, in the survey was mentioned that "Peñalolén obtained the highest rating within the prestigious world ranking "Carbon Disclosure Project (CDP)", a platform promoted by the European Union and other organizations to combat climate change. This thanks to the work on reducing greenhouse gas emissions, protecting water resources and forests, making it the only commune in South America to receive this distinction".

Figure 8: Municipalities climate change networks

Climate Change Trainings (TRAIN)

In terms of Climate change trainings: 46% of the municipalities are conducting training and/or workshops internally within the municipality as well as for the neighbors. Internally the trainings are linked to different studies were municipal officers developed capabilities and tools related with risk reduction and the Municipal Environmental Certification System (SCAM), which is a voluntary environment management system under international standards as ISO 14.001 and EMAS (Community Regulation of Eco-management and Eco-audit). Hereby, municipalities work on recycling, energy and water saving and efficiency in municipal offices. There are also trainings for officials in various environmental issues and development of instruments that promote the participation of neighbors in community environmental management, among others.
Externally, the trainings focus on empowering the citizens through workshops, i.e. according to information of the questionnaire: "Since 2017, 583 workshops have been held, linked to caring for the environment and actions that prevent climate change in the community, in energy efficiency, recycling, reuse, urban gardens, among others". Municipalities which have an important population living in rural conditions focus also in "Annual environmental campaigns on air quality, use of dry firewood, prohibition of agricultural burning, management of critical episodes, among others. Rural environmental education workshops open to the community".

Department of climate change/sustainability (DEP)

An 89% of the municipalities see this variable as an enabler to the implementation of climate adaptation actions. In general terms, a 34% of municipalities have a specific department of sustainability or climate change, some developed a specific new Directorate as is the case of Lo Barnechea and Vitacura, while other developed a sub-department of Sustainability as Santiago and Cerro Navia. There are also cases where the Environment Department was modified and renamed "Department of Environment and Sustainability" as Peñaflor and cases where the Environment, Cleaning and Ornament Department created sub-departments establishing one specific for Environment, Green Areas or Emergency as Maipú, Providencia, Pudahuel, Renca, Puente Alto.

Financial Resources (FR)

A 68% of local governments see this factor as a driver. According to the Mayor's categorization, financial resources, is a variable that allows to see how disaggregated the municipalities are with respect to monetary resources. Municipalities are classified from 1 to 4, being 4 the municipalities with more financial resources and 1 the ones with less monetary resources. There are provinces as Melipilla and Talagante where funds are much more limited compared to, for example, the province of Santiago (*Table 9*).

Table 9: Financial resources classification by province

Province/Classification	1	2	3	4	Total per province
Chacabuco	33%	33%	33%	0%	100%
Cordillera	67%	0%	0%	33%	100%
Maipo	25%	50%	0%	25%	100%
Melipilla	80%	20%	0%	0%	100%
Santiago	0%	41%	34%	25%	100%
Talagante	40%	60%	0%	0%	100%
Total	**19%**	**38%**	**23%**	**19%**	**100%**

Note: This classification ranges from 1-4, where 4 are the municipalities with more financial resources

Staff (STAFF)

It is considered by 90% of the sample as a driver. According to the question "Total amount of functionaries working on climate change projects" A 61% of the municipalities specify that they have people working in climate change issues, the ranges of people differ, from the total amount of people of certain department to just 1 person. It is useful to compare this variable with staff, since this way it is possible to know which municipalities have their staff directly working on sustainability and/or climate change, while in other cases, officials are not dedicated to this matter but rather see many other issues. Within this perspective, only 5% of local governments have people working exclusively in climate change/sustainability while 56% has its functionaries working not only in these issues, but also in other stuff.

Table 10: Summary perception of municipalities regarding drivers or barrier factors

Variable	Driver	Barrier
Framing		
• **Development of climate adaptation plan (CAPL)**	97%	3%
Political factors		
• **Political stability (STAB)**	78%	22%
• **Political cooperation through subsidies & programs (COOP)**	95%	5%
• **Political commitment (COMM)**	95%	5%
Local Governance Capacity		
• **Supportive legislation/regulation (SLR)**	68%	32%
• **Participation in climate networks (NETW)**	95%	5%
• **Climate change trainings (TRAIN)**	97%	3%
• **Specific department of climate change of sustainability (DEP)**	89%	11%
• **Financial resources (FR)**	68%	32%
• **Staff working directly in climate change issues (STAFF)**	90%	10%

4.2 Analysis - Qualitative Comparative Analysis

After running the standard analysis, fsQCA computes three solution, the complex, parsimonious and intermediate solution. In this study the parsimonious solution was chosen because it presents the "core conditions" which are the most relevant conditions that cannot be omit from any result (Pappas & Woodside, 2021). The results of this model were examined in-depth by developing three case studies.

The analysis developed tested the following model:

$$ICCAI = f(CAPL, STAB, COOP, COMM, SLR, NETW, TRAIN, DEP, FR)$$

Algorithm: Quine-McCluskey

Assumptions: All variables present

Table 11: fsQCA Parsimonious Solution

Parsimonious solution	Raw coverage	Unique coverage	Cons.	Cases
CAPL	0,30	0,10	1	Vitacura, Santiago, La Pintana, Peñalolén, Providencia, Renca, Colina, Talagante, Maipú
DEP	0,35	0,13	0,94	Lo Barnechea, Vitacura, Santiago, Peñalolén, Providencia, Renca, Puente Alto, Huechuraba, Cerro Navia, Maipú, Pudahuel
COMM*~FR*STAFF	0,25	0,00	0,93	La Granja, Lo Prado, San Miguel, Paine, María Pinto, Talagante
SLR*~FR*STAFF	0,24	0,00	0,92	María Pinto, San Miguel, Paine, Talagante, Lo Prado

Solution Coverage: **0.61**

Solution Consistency: **0.97**

The consistency of the model and of each configuration is higher than 0.75 which is acceptable (Schneider & Wagmann, 2012) assuring a relationship of sufficiency between the causes and the outcome.

Raw coverage indicates how much of the outcome is explained by a single solution, while unique coverage indicates how much of the outcome is explained by each variable of the solution on its own. The solution coverage explains the total coverage of the solution, that is, the combination of solutions accounts for 61% of the memberships in the implementation of climate adaptation initiatives.

Table 12: Results of parsimonious solution

Variable	Solution			
	1	2	3	4
Development of climate adaptation plan	●			
Political stability				
Political cooperation through subsidies & programs				
Political commitment			●	
Supportive legislation/regulation				●
Participation in climate networks				
Climate change trainings				
Specific department of climate change of sustainability		●		
Financial resources			○	○
Staff working directly in climate change issues			●	●

Note: Black circles indicate presence of the variable and white circles indicate absence of the variable

Parsimonious solution ICCAI consists of four configurations that can be observed in *Table 11*. Configurations 1 and 2 are sufficient and necessary solution on its own to ensure the ICCAI, but the other configurations are combinations of different factors which are complex in the sense that non single factor is sufficient to ICCAI. Nevertheless, within the complexity, config. 3 and 4 are shorter solutions since none of the configurations contains all the factors.

In order to discuss the four configurations, first of all, it is good to have a look at *Table 12*, where the presence of each variable is indicated with a black circle for each one of the solutions and the white circles indicates absence of a variable. For the implementation of adaptation initiatives, solutions 1 and 2 reflect the presence of a unique variable: CAPL (solution 1) and DEP (solution 2), each one being sufficient and necessary. Solution 3 and 4 achieve the same outcome through the absence of Financial Resources and presence of Staff working directly in

climate change, both variables in combination of supportive legislation/regulation (solution 3) or political commitment (solution 4).

By analyzing the model results against the established factors, a first clue can be observed (*Table 13)* in which for Municipalities of the MRS, the presence of Local Government and Framing could be the main enablers followed by Political factors.

Table 13: fsQCA solution according to critical factors

Intermediate Solution	Framing	Political Factor	Local Government Capacities
CAPL	☑ 100%	☒	☒
DEP	☒	☒	☑ 100%
COMM*~FR*STAFF	☒	☑ 33%	☑ 67%
SLR*~FR*STAFF	☒	☒	☑ 100%

Accordying to the methodology explained in *section 3.4.3 Third approach: Case Studies*, three case studies were selected to interpret QCA results in a more in-depth manner.

The cases were selected according to two principles: diverse case selection and unique membership. To see graphically which cases are the ones with the better consistency and coverage, the XY plot offers an analytical and easy way to appreciate it. According to Schneider & Wageman (2012), cases that are situated above the diagonal indicates a sufficient relation. And contrary, cases under the diagonal are necessary. Further, the closer are the cases to the main diagonal, the better the coverage and the ideal situation is when a case is in line with the diagonal because it has maximum coverage and consistency.

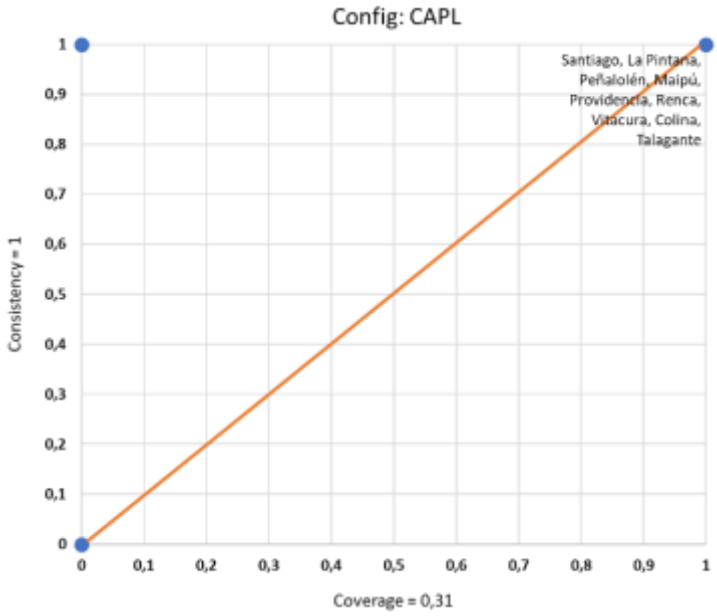

Figure 9: Plot solution 1 fsQCA

Principle of unique membership: the sets CAPL & DEP are the only factors that are sufficient and necessary to the outcome (*Figure 9; Figure 10*). In the case of configuration CAPL, there are a vast number of cases that are in the perfect alignment with the diagonal, showing a perfect relation of sufficiency and coverage. The case selected was aleatory since all the cases above the line have developed a CAPL. The in-depth analyses through a case study will show more information about the impact of this factor and how it facilitates, articulates, and transversally promotes its commitment among different actors.

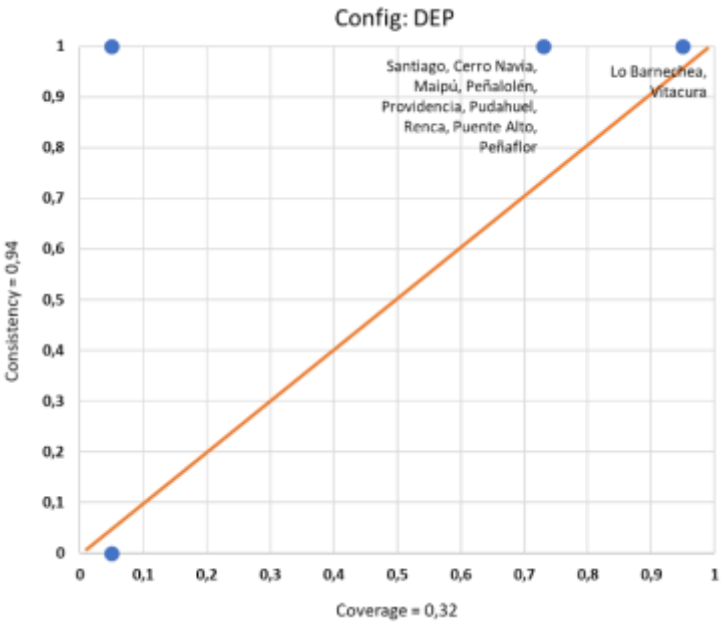

Figure 10: Plot solution 2 fsQCA

DEP also boost the implementation of climate adaptation initiatives by its own. There are only two options that have developed a specific Directorate of sustainability. From both options, Lo Barnechea was chosen. A deeper analysis of how this local government is doing things might explain why this factor by its own ensures the efficient execution and administration of resources and projects.

Regarding the principle of diverse selection, for COMM*~FR*STAFF and SLR*~FR*STAFF configuration, the same case (María Pinto) was selected thus according to the model (*Figure 11 & 12)* this case is the one with better coverage and has empirically data that justify the outcome.

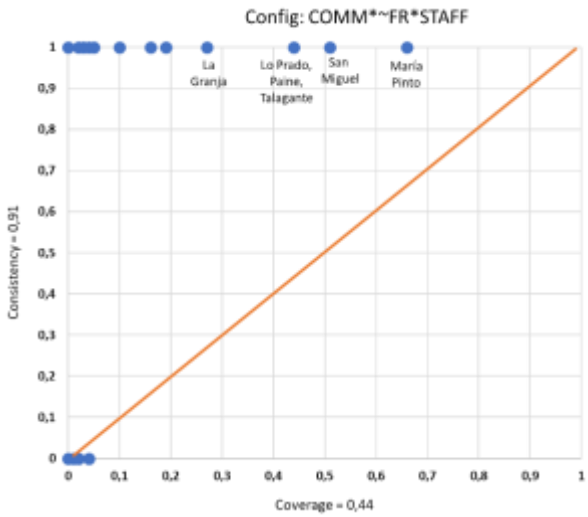

Figure 11: Plot solution 3 fsQCA

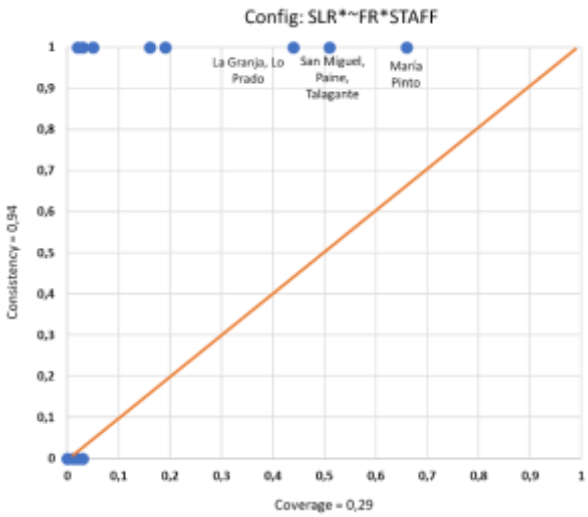

Figure 12: Plot solution 4 fsQCA

4.2.1 Providencia - CAPL

Photograph 1: Commune of Providencia (source Municipal website)

The commune of Providencia is in the Province of Santiago and has a central location in the metropolitan area. Its territory has an extension that represents the 0,43% of the regional surface and is expose to several risks as flooding, fires, landslide zones, urban heating, and strong winds (PLCC Providencia, 2015). The local authority is part of the RedMuniCC association, which helped them to **framed adaptation** by developing a CAPL identifying the main strategic action and plans. Further it has a specific climate change policy and the presence of climate change it insert in different policies along the organization such as PLADECO. In the official website of the municipality there is a lot of information about environmental awareness and a special section is assigned for climate management, where six pillars are prioritized: Water Efficiency and Safety; Energy and waste; Risk, threat, and response capacity management; Health; Biodiversity, environmental services, and green areas; Infrastructure.
Also, the projects related to climate change can be found and they specify 14 concrete measures i.e., the construction of 28 km of bike lines. In terms of **trainings**, the municipality of Providencia annually conducts academies for neighbors on sustainability topics such as the ones mentioned in the survey "critical resources water and energy, waste management academy (repair, organic / inorganic recycling, among others), scientific cafes next to the institute of ecology and biodiversity, sustainable consumption, climate change and citizen action". They organized between 3 to 5 annually academies each one with 4 sessions as minimum. The scientific cafes have 6 sessions. The local government also has a department of environment, and **8 functionaries work on climate change projects**. A 2,5% of their budget goes to climate change initiatives.

The Municipality **participate in four associations**, RedMuniCC, Pacto de Alcaldes por el Clima y Energía, Programa Huella Chile and Carbon Disclosure Project (CDP). Between 2015 and 2019 the local government actively joined the project *Cities fit for climate change* organized by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. In the survey they mentioned: "For the specific case of cooperation with Providencia, GIZ conducted a series of trainings to develop an integrated urban planning strategy as a pilot exercise. This was developed during the year 2018 and consisted of seven workshops with municipal officials from different units (SECPLA, Environment, Urban Advisory, DIDECO, Transit) in which the methodology of integrated strategic planning with a focus on adaptation to climate change was addressed. To close this training, a study trip was made to Germany (Berlin, Leipzig and Halle) in which two professionals from the Department of Urban Consultancy participated. In the framework of cooperation with GIZ, four professionals from the Municipality (Department of Traffic and Urban Advisory) were invited to participate in the Summer School 2018 (Sustainable Mobility-Made in Leipzig with the focus on Sustainable Mobility"

One of the successful adaptation initiatives that was developed was the Local Water Strategy, a municipal management tool that was born as an initiative of diagnosis, planning, and cultural

reflection on water. Taking into consideration the Chilean reality, context of scarcity and the effects derived from climate change, this instrument proposes a roadmap for taking actions in the short, medium, and long term. Throughout, the Municipality of Providencia plans to advance towards a sustainable use of water, sensitizing and involving all sectors of the citizenry in the commune.

The pillars of this strategy are: 1. Water Safety 2. Irrigation management 3. Water Culture 4.Water Governance

Among the most successful concrete actions, the following stand out from the questionnaire:

"1. The sidewalks with slits were redesigned to prevent rainwater from running through the streets and ending up in drains
2. The modification of an ordinance to replace grass, which has a high-water consumption, with a list of plants and ground covers that resist prolonged droughts.
3. Automation of irrigation: with humidity sensors and specialized software
4. Tree renewal: 4,000 trees have already been planted in three years and this will be increased with species adapted to a semi-desert climate (…)"

The critical enablers for those implementations that were sated by the authority are CAPL, COMM, FR.

4.2.2 Lo Barnechea - DEP

The Municipality of Lo Barnechea is an extensive territory that represent the 45,5% of the Province of Santiago. 96% of the area is considered ecological preservation, with a geography that is characterized by containing glaciers, mountains as well as endemic species. The main watercourse of the city of Santiago rises here, the Mapocho River, which at the end of 2019 presented an 84% lower flow to the average of the last 30 years, which led the General Water Directorate of Chile to decree water shortages for the first section of this stream, which includes this territory. Climate change is an issue that has impact the commune and although Lo Barnechea has not developed a Climate Change Adaptation Plan yet[4], it has made other advances which can materialize in the implementation of climate adaptation measures.

Photograph 2: Commune Lo Barnechea (source Municipal website)

This Municipality is one of the two of the RMS that have developed a **specific Directorate of Sustainability** creating an exclusive department of "Environmental Strategy" with two sub-departments of "Performance improvement" and "Public integrity". They count with 6 functionaries working exclusively on climate change issues and 0,3% of their annual budget is

[4] In the Survey was mentioned that the topic is addressed in the Municipality Environmental Strategy that is being developed

derivate to climate projects, which is a significant amount considering that this local government is positioned among the 6 municipalities with higher financial resources of the MRS. By decree of law, the organic structure of the municipality with their respective powers, functions and attributions of the municipal units are established. In the case of Lo Barnechea, the functions of this Directorate cover many of the factors that were evaluated in the model.
Regarding **political commitment**: In 2019 they developed an official commitment on sustainability by declaring their compromise with the 2030 Agenda of the Sustainable Development Goals (SDG). Five SDG were prioritized (SDG 1 No Poverty– SDG 3 Good Health and Well-Being – SDG 4 Quality Education – SDG 11 Sustainable Cities and Communities – SDG 15 Life on Land). For each one of the goals, specific initiatives were specified which shows that projects are being developed that go beyond groundwork level actions but rather adaptation level implementations i.e., the construction of new parks representing 680,000 m2 of new green areas.
An environmental policy was also developed in 2020, in which one of the specific objectives declared is to generate responses to climate change through prevention, mitigation and adaptation measures. Through **cooperation through subsidies and programs**, the local government has developed:
1) My sustainable school project: $ 55,000,000CLP from the Energy Sustainability Agency. The fund is not paid directly to the Municipality, but it pays for 50% of the project directly with the company that executes it.
2)Territorial Agreement for Water Efficiency: $ 25,000,000CLP Fund of the Agency for Sustainability and Climate Change.
About the **trainings**, the municipality has a program of environmental education, and two trainings were done during 2020. Internally, one of the roles of the Sustainability Directorate is to propose general and strategic guidelines on environmental matters, which consider all the relevant municipal units, facilitating their coordination and promoting coherence of action. This is important to avoid working in silos and collaborate with other units by promoting transversality of actions and projects.

In the survey, an example of a successful implementation of climate adaptation initiative is the working that Lo Barnechea is doing regarding wetlands: “In January 2020, Law No. 20,202 was approved, which modifies various legal bodies with the aim of protecting urban wetlands, known as the Urban Wetlands Law. Considering the above, the Sustainability Directorate prepared a wetland cadaster of the commune, identifying more than 700 wetlands, of which approximately 70 are located in the urban area. Given this and given the importance of these ecosystems to combat climate change, work is being developed to ensure the protection of wetlands, (…). This resulted in the first urban wetlands declared at the national level: Tranque la Dehesa and Embalse Larraín. In this sense, work continues submitting new applications for the declaration of wetlands and preparing a tender in order to characterize or later restore the ecosystems of urban wetlands, and a local ordinance in this regard.”

According to the local authority the three main factors which enables the development of the wetland initiative are Political Commitment, Specific Department of Sustainability/Climate Change and Staff working directly in Climate Change.

4.2.3 María Pinto - COMM*~FR*STAFF and SLR*~FR*STAFF

María Pinto is a rural commune, in which large areas of land are dedicated to the production of fruit and vegetables. Among these large productions are located small, populated centers somewhat isolated from each other, with a small urban area where civic activities and other public services take place. (PLADECO, 2018). The local territory faces climate change due to the historical agricultural and livestock activities, deforestation, and the numerous fires. This locality is part of the province of Melipilla, has political stability by being the last 25 years under the same political coalition and is categorize under **low-income municipality** (to get an idea the annual budget per inhabitant is ~ 13.22 euros), but this last factor is not a limitation for the commitment that they have regarding Climate Change.

Photograph 3: Commune María Pinto (source Municipal website)

In 2020 they developed their environment policy in which one of their three strategic development areas was supporting governmental climate change measures. In the same document the **municipality's commitment** to the 2020 Agenda for Sustainable Development was established and 6 lines of action were specified (SDG: 6-7-11-13-14-15), being number 13: Climate action.

Regarding trainings or guidance, the local authority has related trainings in waste management, recycling, biodiversity, forest, wetland Puangue and they are working for setting a technical table for the development of a water strategy in the territory. In addition, they received a specific subsidy/program to delve into climate studies, where the recycling supervisor joined the "Diploma on Climate Action and Municipal Management" which later will be used to provide specific trainings on climate change adaptation, such as gray water treatment, rainwater harvesting, solar dehydration, among others.

Accordying to the survey performed an 1% of their annual budget is assign to climate change issues "All DIMAO activities are aimed at preserving, caring for and reducing the environmental impact or effects of human activity in the commune". They don't have a specific department of climate change or sustainability, but they are working on developing an Environment Directorate. Currently 4 functionaries are working on climate change projects, although its functions are not working exclusive in this matter. They are also part of different networks as Fundación Chile, RedmuniCC and they participate in associations such as AMUSA and Sustainability Agency for Climate Change.

Among the successful ICCAI, in the questionnaire was mentioned:

"The Urban Forest planted with an ecological restoration technique, in a process that involved the community"

"The recognition of the Urban Wetland, one of the main mitigators of climate change"

“With the community, campaigns about environmental education in waste management were developed, so that they recycle and compost, we have a home removal service, and this is taking care of our environment, because we also try to instill that they are responsible consumers and should try to generate less waste.”
According to María Pinto the more important enablers for ICCAI are: Supportive legislation/regulation, Political cooperation through subsidies & programs and Political commitment.

4.2.4 Case studies summary

As can be seen through the analysis of case studies, more in-depth information can be recorded that explains why certain configuration can rely on just one factor to ensure the implementation of climate adaptation actions, while other sets compromise more than one factor. In the case of Lo Barnechea it can be appreciated that the extension of their organizational chart by creating a new Directorate of Sustainability implies a series of functions that were established by decree of law, which contain certain factors that are considered enablers as commitment, staff working directly in climate change issues, resources to the development of the projects, coordination among different municipal departments. In the case of Providencia, it can be appreciated that by having a CAPL, more information about the state of the municipality regarding the threats and vulnerabilities it faces can be found. This makes it easier to determine lines of action and then prioritize initiatives and implement them. In addition, it is observed that this municipality participates in several nationals and international associations, which could be explained by the access, exchange of information, subsidies and programs that a CAPL gives to the municipality. Finally, María Pint, is the example of a Municipality that doesn’t count with a big budget, but even though through commitment and participation in climate change networks, it could opt for grants and programs that facilitates the implementation of actions. This shows that without financial resources, if local authorities are committed and take action for what they consider important, great things can be done. This does not mean that financial resources are not important, since they can make things easier anyway, but it is not essential.

4.3 Findings

After analyzing the current situation of the municipalities in *section 4.1 Analysis - Current state of municipalities regarding CCA* there was one factor that was expected to be relevant also in the model, that was the case of CAPL. According to this analysis, having developed a CAPL gave the municipalities more tools to implement adaptation measures which was reflected in the fact that greater percentage (68%) of municipalities that developed those plans implemented adaptation-level initiatives. These types of initiatives are tangible and go beyond the mere development of plans and programs. When complementing this information with the results of the model in *section 4.2 Analysis - Qualitative Comparative Analysis* it becomes much clearer why this factor alone is sufficient for the ICCAI, since the relationship between factors can be understood and further conclusion can be achieved. First, the only network that provides the support and guidance service for the development of a CAPL is RedMuniCC. Given this, it is necessary for a municipality to be part of this network to develop a CAPL. Second, being part of the network includes many more benefits than just developing the CAPL. In fact, prior to the plan, there is an information gathering to develop the climate profile of the municipality, where the risks and vulnerabilities of the territory are defined. At the same time, the process for the Municipal Environment Certification (SCAM) starts, which is one of the measures that is promoted in Chile’s National Adaptation Plan. The next step includes a series of trainings regarding climate change, as well as Climate Change Academies (which were

detailed in the Providencia case study). Finally, the process concludes with the development of the CAPL, and certain transversal elements of the process such as the communication and participation strategy, the joint raising of funds for implementation and the follow up of the plan compliance, which requires staff working on it (Adapt Chile, 2017).

With all this information, it is understandable that the municipalities that have developed these plans have greater clarity and implementation of adaptation level type of projects. In addition, the process of developing a CAPL is very complete, which is also reflected in the fact that municipalities that have developed it, have access to a greater number of subsidies/programs than the others, as well as a greater participation in climate and sustainability networks and trainings. From the secondary data analysis, the municipalities that have CAPL, a 100% provides or received trainings and in the case of cooperation through subsidies or programs, 67% have received it, versus a 19% of local governments that don't have a CAPL. Further, local governments with a CAPL are more likely to develop supportive regulations in the sense of having more internal and cross-cutting climate change policies. Then the implication of having a CAPL is the facilitation and presence of drivers such as TRAIN, COOP, SLR, STAFF, COMM, NETW.

Regarding the second sufficient variable from the model, Specific department of sustainability or climate change, unlike CAPL, in section 4.1 Analysis - Current state of municipalities regarding CCA, there was no impression that this variable would play a relevant role. However, when looking at the model and analyzing the case study, it can be seen that something similar to CAPL happened, since having a DEP indirectly includes more variables than there can be seen with naked eyes. The fact that a municipality decides to expand its organization chart and establish a specific area to deal with environmental issues, means that it implicitly has personnel working in that area and that there is a commitment to the cause, in Lo Barnechea case study this can be appreciated. Further, secondary data supports the fact that 100% of these organizations have at least one person working on climate issues, in addition to a 100% that is conducting various trainings and workshops. But when comparing this variable with CAPL, DEP covers less variables than CAPL, in the sense that for example, not every municipality that has a DEP, is part of a network. Further, less cases have received COOP (40%) and the access to subsidies and/or program (45%) is less than CAPL. Hence, if you are a commune with fewer resources, it is better for you to opt for a CAPL since that will required less fixed costs and increase the probability of funds access.

When analyzing COMM*~FR*STAFF and SLR~FR*STAFF the first thing that caught attention is the absence of financial resources because according to literature, this variable tends to be considered of utmost importance (Ryan, 2015; Runhaard, 2017; Aylett, 2014) but giving this result, is no longer leading to the ICCAI. This implication questions the results of previous studies in which financial resources plays the central role for implementation. Although this factor can contribute and facilitate certain resources, it is a variable that is not sufficient or necessary in any other configuration, and in these sets, its absence is not a reason for impediment or restriction. This could be appreciated in María Pinto case study, a local government that lacks monetary resources, but it is still capable of implementing climate adaptation initiatives. When going in depth in María Pinto case study, there is a factor that doesn't showed the model, but it can be appreciate through the case study and its relevant, that is the participation of María Pinto in many associations and networks that provide support. Further by analyzing the plots (*Figure 11* ***Error! Reference source not found.****&12*) of *section* *REF _Ref80785078 \h * MERGEFORMAT 4.2 Analysis - Qualitative Comparative Analysis*, and see the cases situated in the "Typical cases" area which ensures sufficiency and good

empirical instances of the outcome[5] (Schneider & Wagemann, 2012), all those cases are part of RedMuniCC. Because some have recently joined, they have not yet developed CAPL, but as we saw before in this section, belonging to the RedMuniCC network provides a large number of benefits, such as training and facilitating access to subsidies and/or national/international programs. When analyzing these results against *section 4.1*, there is no strong relationship that can be established between this result and the actual implementation of adaptation measures. Although the model led to this, in reality there is no follow-up, official document or guide that allows through this set of factors to determine whether a municipality is actually implementing adaptation measures or not. Bringing out the problem that was presented in section *4.1.3 Status of projects*, in which the low reportability is a disadvantage and prevents to known if an adaptation measure is actually being implemented or not.

Chapter 5: Conclusions and recommendations

The purpose of this research was to identify the factors that enable the implementation of climate adaptation initiatives within the Municipalities of the MRS. In addition, the study attempted to examinate the current state of Municipalities regarding climate adaptation. It adds to the current academic knowledge about climate adaption since mostly studies are focus on Europe and North America only 10% in South America (Owen, 2020). Therefore, even though there is a context-specific limitation to this research it brings insights that could serve other Latin American municipalities and countries. The research uses a combination of methodologies that could be replicated in a systematic way. Using QCA, facilitates the examination of complex previously recognized factors, that interrelate with one another and affect the implementation of climate adaptation initiatives. Contrasting this QCA model with the current state of municipalities regarding climate adaptation facilitates reaching conclusions in a robust way with both empirical and academic information. Future research might consider QCA to asses' complex social relationships, not as a replacement to other statistical method as regression, but as a complementary procedure (Ftizgerald, 2019).

After the evaluation of each of the four solutions within crossed information from *section 4.1 Analysis - Current state of municipalities* regarding CCA *& 4.2 Analysis - Qualitative* Comparative Analysis it can be determined that the only solution which is supported by secondary and primary data, from official documents and the questionnaires carried out was solution 1: CAPL. After the findings we noticed this variable by itself is capable of ICCAI, only because it is already implicitly related to TRAIN, COOP, SLR, STAFF, COMM and NETW. Therefore, *Figure 13*, proposes a new model. From *section 4.1* Analysis - Current state of municipalities regarding CCA it can be concluded that with respect to the current state of the municipalities of the MRS, there is a reportability problem that makes it difficult to determine whether all the classified initiatives have become implemented or not. This agrees with the study of Carmin et. al, (2016) and Araos (2016) where it was evidenced that in South America there was a high engagement in adaptation, but not many actions ended being implemented. In MRS, thanks to the information provided by the climate adaptation plans, there is more data that contribute to the knowledge of the status of the implemented actions and for the same reason is that this variable can be seen as one of the main drivers of ICCAI.

[5] For detail explanation see section *3.4.3 Third approach: Case Studies*

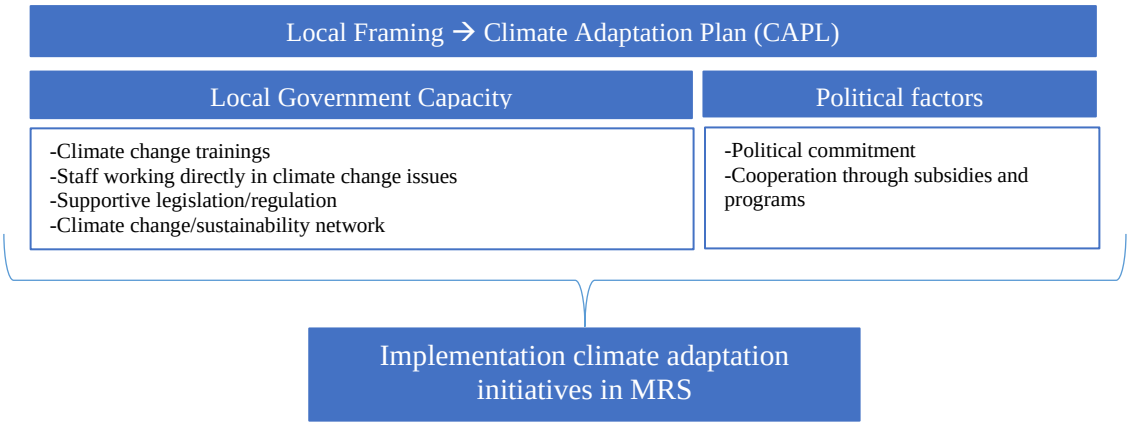

Figure 13: Model proposal MRS implementation of climate adaptation initiatives

Further, as was seen in this research, these plans involve many other factors as well as working in integrating information from different government levels, as the national adaptation strategy. It also counts with support from international and national public-private agencies. This cross-cutting characteristic through policy mixture is the most challenging part of the adaptation plan, but at the same time makes it a robust and complete policy whereby adaptation can be analyzed and compared with other territories. The following is in line with recent studies of Lesnikowski et al., (2019), the World Bank (2019) and Ford et al. (2016), in which Climate Adaptation Plans are seen as a mainstreaming instrument to facilitate the comparison, analysis and tracking of implemented adaptation actions.

Furthermore, CAPL also provide with information about the main risks, vulnerabilities, and each past and present action according to certain thematic area (water, waste management, culture and identity, infrastructure, among others). With that information it was possible to determine how adaptation is being implemented in MRS: 1. By the support of the CAPL and its alignment with other policies at different government levels, and 2. through the prioritization of certain thematic areas as ecosystem, culture, and waste management in the case of the province of Santiago and water in the case of Chacabuco[6]. There is a prominent need to develop generic assessments and standardization of adaptation implementation actions. It is something that has been broadly discuss in literature (Ford et al., 2016; Araos et al., 2016), specially because climate change funds around the globe are increasing and there is a need for transparent information about climate priorities and status of actions. Therefore, CAPL come to fulfill this role in the MRS.

Once the current state of implementation in the MRS was clear, it was possible through the QCA and the case studies to understand what factors were key for implementation. According to recent literature 3 major factors were evaluated: Framing, Political factors, and Local Governance Capacities (Ryan, 2015; Runhaar et al., 2018; Di Giulio et al., 2019). As was seen in *section 2.3.2 Framing factor* and according to Fünfgeld et al. (2012), adaptation can be framed at three different levels not exclusively, the meta level where adaptation is insert in values and public policies, the conceptual level, where authorities developed frameworks, and the operational level, where actions are implemented. The CAPL are instruments that comply with integrating national policies at the local level, develop climate profiles and at the same time provide tools to implement those actions. Given the above, these plans are a good indicator to evaluate framing and ensure that local government are align to national strategies.

[6] For detail information see *section 4.1 Analysis - Current state of municipalities regarding CCA*

Additionally, the only entity that offers the development and support for CAPL is RedMuniCC, which allows all municipalities to be under the same evaluation, having plans that can be compared and analyzed within the same criteria.

Regarding political factors, the main elements to consider for the ICCAI are commitment and cooperation through subsidies and programs. These results are in line with Runhaar et al., (2018) where commitment and subsidies are among the highest enablers detected in adaptation outcomes. Further, Di Giulio et al., (2019) and Ryan (2015) also empathizes in both factors to facilitate the implementation of climate initiatives, considering that climate change is an issue that at first glance competes with health, education, housing, and other municipal priorities. It is worth mentioning that the variable political stability was left aside, since as mentioned in *section 4.1.4 Perception of main drivers,* the municipalities of the RMS have so far been very stable and the small changes that have occurred did not impact the implementation of adaptation measures. As Ryan (2012; 2015) mentions, climate change is not an issue that has been politicized yet, so it remains stable.

Finally, the main enablers for the implementation of adaptation initiatives from a Local Governance point of view are Trainings, Staff, Network and Supportive legislation/regulation. Every one of these factors is also present in recent literature analysis. The only factor that attracts attention that is not prioritized is financial resources (Ryan, 2015; Runhaar et al., 2018; Di Giulio et al., 2019), which may be happening since municipalities with limited resources can participate in RedMuniCC, have greater access to subsidies and/or programs, thus indirectly have funds to implement these initiatives. This information is very precise and context specific. Hence, Owen (2020) was right in his study that adaptation is shaped by its context, making it difficult to replicate or evaluate the same framework in different countries and/or initiatives.

According to Ford et al. (2010), 67% of adaptative initiatives are implemented at local level. Through this study its known that the implementation of adaptation initiatives in RMS occurs in a better way and with greater tools in the case of municipalities that have developed CAPL. Therefore, the municipalities that haven't joint RedMuniCC should evaluated to join it, to boost its resilience, map their vulnerabilities and risks, incorporate new knowledge, and participate in workshops and climate trainings. Thus, they will be able to develop a territory that ensures the security and prosperity of their people and the ecosystem.

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Annex 1 : Questionnaire for Municipalities

Climate Adaptation initiatives Questionnaire

Please indicate in the in the box your consent to participate in this study ☐

Part A. Local governance capacity

The following questions are designed to collect information on your local capacity to face climate change challenges in two key areas: Resources and Organizational factors.

A1. Your municipality has a policy of climate change?

Yes ☐ No ☐

A2. Your municipality has developed a Climate Adaptation Plan?

Yes ☐ No ☐

A3. Your municipality has training or guidance related to climate change?

Yes ☐ No ☐

A3.1. If your answer in A3. was Yes, Which trainings or guidance?

_____
_____
_____
_____
_____
_____

A3.2. If your answer in A3. was Yes, how many people attended to those trainings/guidance's?

Number ☐☐☐

A4. Total amount of functionaries working on climate change projects

Number ☐☐

A5. Percentage of annual budget assigned to climate change issues?

Percentage ☐

A6. Do you have a specific department related to sustainability or climate change?

Yes ☐ No ☐

A7. Does your municipality participate in climate change or sustainability associations?

Yes ☐ No ☐

A7.1. If your answer in A7. was Yes, in which climate change or sustainability associations participate?

_____
_____
_____
_____
_____
_____

A8. Does your municipality received specific subsidies, programmes for developing climate adaptation initiatives

Yes ☐ No ☐

A8.1. If your answer in A8. was Yes, which specific subsidies, programmes for developing climate adaptation initiatives did you received?

_____
_____
_____
_____
_____
_____

A9. Your municipality is aligned to the climate change strategy of the national level?

Yes ☐ No ☐

A10. If you would have to prioritized certain municipal work axes, would climate change be in the first 10 topics of prioritization?

Yes ☐ No ☐

A10.1. If you would have to prioritized certain municipal work axes, would climate change be in the first 5?

Yes ☐ No ☐

A10.2. If you would have to prioritized certain municipal work axes, would climate change be in the top 3?

Yes ☐ No ☐

A11. Is climate change adaptation integrate into other policies among other departments of the municipality?

Yes ☐ No ☐

Part B: Implementation of climate adaptation initiatives

The questions in this section are designed to collect information on the implementation of climate adaptation initiatives by sector which aim is to analyze how the actions are being prioritized and which factors influence in the implementation of adaptation actions.

B1. Regarding the implementation of climate adaptation initiatives. In which sector predominate their implementation?

Mark up to three sectors

- ☐ Infrastructure
- ☐ Environment
- ☐ Health
- ☐ Education
- ☐ Technology
- ☐ Culture
- ☐ Emergency management
- ☐ Water
- ☐ Transport
- ☐ Energy
- ☐ Indeterminate
- ☐ Other – Specify which one: _____

B2. Regarding the implementation of climate adaptation initiatives. Define weather each factor is view as an enabler or barrier.

		Mark One in Each Column **Enabler**	**Barrier**
a.	Development of climate adaptation plan	☐	☐
b.	Chilean Climate change national strategy.....	☐	☐
c.	Supportive legislation/regulation	☐	☐
d.	Participation in climate networks	☐	☐
e.	Political short-termism.....	☐	☐
f.	Political stability	☐	☐
g.	Political cooperation through subsidies & programs	☐	☐
h.	Political leadership, by participation in transnational networks	☐	☐
i.	Political commitment.....	☐	☐
j.	Political short-termism.....	☐	☐
k.	Climate change trainings	☐	☐
l.	Specific department of climate change of sustainability	☐	☐

m.	Financial resources	☐	☐
n.	Staff working directly in climate change issues	☐	☐

B3. Could you provide an example of a successful implementation of climate adaptation initiative?

_____
_____
_____
_____
_____
_____
_____
_____
_____

B3.1. In the case of the previous example, which factors were crucial for its success?

		Mark up to three factors **Factors**
a.	Development of climate adaptation plan	☐
b.	Chilean Climate change national strategy.....	☐
c.	Supportive legislation/regulation	☐
d.	Participation in climate networks	☐
e.	Political short-termism.....	☐
f.	Political stability	☐
g.	Political cooperation through subsidies & programs	☐
h.	Political leadership, by participation in transnational networks.....	☐
i.	Political commitment.....	☐
j.	Political short-termism.....	☐
k.	Climate change trainings	☐
l.	Specific department of climate change of sustainability.....	☐
m.	Financial resources	☐
n.	Staff working directly in climate change issues	☐

Thank you for your time!

Annex 2: Sample Municipalities of the MRS

The sample of this study consists in 52 municipalities, that are divided into 6 different provinces, each one with different spatial and physical characteristics.

Figure 14: Provinces in the MRS

Province of Santiago:

The province of Santiago constituted of 32 communes, and it concentrates 73,7% of the regional population. According to the data from the 2017 Census and projections of INE, the Province of Santiago has 6,075,403 inhabitants (INE, 2021). The population density is the highest in the country.

Table 14: Responses Questionnaire Municipalities Province of Santiago

Municipality	Population 2021	Questionnaire respondent	Municipality	Population 2021	Questionnaire respondent
San Ramón	86.017	Yes	Cerro Navia	142.304	Yes
Cerrillos	89.520	Yes	Independencia	147.655	Extension
Vitacura	97.695	Yes	Providencia	160.043	Yes
La Reina	100.459	Extension	Renca	161.959	Yes
La Cisterna	101.126	Yes	El Bosque	171.789	Yes
Lo Espejo	103.381	Yes	La Pintana	189.454	Yes
San Joaquín	103.871	Yes	Recoleta	193.605	Yes

Lo Prado	104.405	Yes	Estación Central	214.470	Yes
Pedro Aguirre Cerda	107.409	Yes	Ñuñoa	255.823	Yes
Huechuraba	114.453	Yes	Pudahuel	256.607	Yes
La Granja	122.028	Yes	Quilicura	261.993	No
Lo Barnechea	126.816	Yes	Peñalolén	269.296	Yes
Macul	136.278	No	Las Condes	335.296	Yes
San Miguel	136.835	Yes	La Florida	405.185	Yes
Quinta Normal	138.904	Yes	Santiago	517.280	Yes
Conchalí	139.394	Extension	Maipú	584.053	Yes

Figure 15: Municipalities of the Province of Santiago

Province Cordillera:

It is located to the southeast of the Metropolitan Region in the border with Argentina. It has three municipalities (Alto, San José de Maipo and Pirque). It is an area with 705,084 inhabitants (INE, 2021) which represent an 8,6% of the MRS (Subdere, 2021).

Figure 16: Municipalities of Cordillera Province

The Provincial Capital is Puente Alto, the municipality with the largest number of inhabitants of Chile with an estimated of 655,033 inhabitants (INE, 2021). It is characterized by being a dormitory commune, in which the population commute to another area of the city to work.

San José de Maipo is the territory with the largest surface area in the Metropolitan Region, with 5,070 km2. Tourism is one of the main productive goods and services from the area (Subdere, 2021).

Table 15: Responses Questionnaire Municipalities Cordillera Province

Municipality	Population 2021	Questionnaire respondent
San José de Maipo	18,917	Yes
Pirque	31,134	Yes
Puente Alto	655,033	Yes

Province of Talagante:

This province is located in the southwest of the center of the Metropolitan Region, in the middle of valleys that run through the coastal mountain range towards the central coast. The estimated population is of 343,209 inhabitants (INE, 2021; Subdere, 2021).

Figure 17: Municipalities of Talagnate Province

Table 16: Responses Questionnaire Municipalities Talagante Province

Municipality	Population 2021	Questionnaire respondent
El Monte	40,620	Yes
Isla de Maipo	40,803	Yes
Padre Hurtado	76,219	Yes
Talagante	82,900	Yes
Peñaflor	102,667	Yes

Province of Chacabuco:

Figure 18: Municipalities of Chacabuco Province

This province is located at the northern end of the capital and is made up of the communes of Colina, Lampa and Til-Til. This province has an area of 2,076.1 km2 and an estimated population of 338,818 inhabitants (INE, 2021; Subdere, 2021). This territory is characterized by a high percentage of population that lives in rural conditions (20,7%) with agricultural activity and the urban area with mainly industrial and real estate activity.

In this territory limestone extraction is an important economic activity and the area is also known for its abundant production of prickly pear and olive trees (Subdere, 2021)

Table 17: Responses Questionnaire Municipalities Chacabuco Province

Municipality	Population 2021	Questionnaire respondent
Tiltil	21,783	No
Lampa	131,436	No
Colina	185,599	Yes

Province of Maipo

Figure 19: Municipalities of Maipo Province

It is the southern access to the Metropolitan Region. It has 564,375 inhabitants (INE, 2021).

This Province is divided by the Maipo River and the North-South Highway, also bordering the Provinces of Cordillera, Santiago, Talagante, Melipilla and Cachapoal (Subdere, 2021)

Among the attractions is The Altos de Cantillana Biodiversity Reserve found in the Paine commune with 205 thousand hectares (Subdere, 2021)

The Aculeo lagoon was also very visited by tourists due to their proximity and their beautiful landscapes, but since climate has change and precipitation decrease, finally in 2018 the lagoon was completely dried up (Subdere, 2021)

Table 18: Responses Questionnaire Municipalities Maipo Province

Municipality	Population 2021	Questionnaire respondent
Buin	111,934	Yes
Calera de Tango	29,019	Extension
Paine	84,379	Yes
San Bernardo	339,043	Yes

Province of Melipilla

Figure 20: Municipalities of Melipilla Province

Melipilla is one of the provinces of the Metropolitan Region with the largest rural area. It has an estimated of 21,5570 inhabitants (INE, 2021) of which 45,5% belong to the rural area. It is made up of five communes, which represent in territory an area equivalent to 26% of the territory of the Region.

This province has strong representation of the agricultural sector. Among the main attractions of the province, is Pomaire where crafts and pottery can be found (Subdere, 2021).

Table 19: Responses Questionnaire Municipalities Melipilla Province

Municipality	Population 2021	Questionnaire respondent
Alhué	7,536	Yes
Curacaví	36,991	Yes
María Pinto	15,132	Yes
Melipilla	143,779	No
San Pedro	12,132	No

Annex 3: Variables excluded from the model

Meta level

In the questionnaire to municipalities 100% of the respondent agree that the National Climate change strategy is an enabler to the implementation of climate adaptation initiatives.

To analyze the meta level in depth and see if adaptation is inserted in national public policies a review of the main instruments in Chile was evaluate starting with The National Adaptation Plan. This plan was one of the goals established in The National Climate Change Strategy and supports the conceptual basis and principles for adaptation in Chile. It also articulates the sectorial plans that were defined as urgencies: Forestry, Biodiversity, Fisheries and Aquaculture, Health, Infrastructure Services, Cities, Energy, Tourism and Water resources. In global perspective, there are guidelines and climate adaptation is insert in policies through the development of these plans. Hence, when analyzing the role of municipalities in those plans (*Table 20*) it can be concluded that only two policies (Climate Change Adaptation Plan for Cities & Climate change adaptation plan for biodiversity) have concrete actions and goals where Municipalities are responsible of the development of certain procedures, which make sense considering that those are the main sectors where municipalities can contribute by well administrating the territory of it development in terms of economic, social and cultural aspects. In *Table 21*, the summary of actions can be observed. Further *Table 22*, merge the line of actions of *Table 21* with the questionnaire of Municipalities to see in detail what are Municipalities doing regarding climate change adaptation.

In terms of analysis, this information could be coded under the variable Climate Change National Strategy but would behave as a constant for all cases since there is effectively framing at the meta level. Therefore, it could be omitted of the analysis since it does not contribute or differ in each case, rather its presence always contributes to the same direction, not generating significant impacts.

Table 20: Role of Municipalities at different policy levels

Policy	#*	Purpose
National Strategy Climate Change	74	-Strengthen and improve the institutional framework for climate change - permanent manager or a Climate Change unit -General working guidelines -Boosting programmes, trainings and certifications related with environment and climate change -Collaborators of energy projects -Municipalities as responsible for developing adaptation plans
Climate Change Adaptation Plan for Cities	41	-Strengthen and improve the institutional framework for climate change - 60% of the time municipalities were referred in concrete actions appointing them as co-collaborators -40% of the time municipalities were referred in concrete actions appointing them as responsible of specific actions
Climate change adaptation plan for biodiversity	26	-75% of the time municipalities were referred in concrete actions appointing them as co-collaborators -25% of the time municipalities were referred in concrete actions appointing them as responsible of specific actions
National Adaptation Plan	22	-Boosting certifications as SCAM (municipal environmental certification) and SNCAE (National Environmental Certification for Educational Establishments) -General working guidelines (i.e., voluntary participation in CORECC (Regional Committee of Climate Change) -Financial sources -Municipalities as co-responsible of developing the City sectoral adaptation plan

Climate Change Adaptation Plan Health Sector	9	-General working guidelines
Climate change infrastructure services action plan	4	-General working guidelines
Climate change adaptation plan for forestry and livestock	0	
Fisheries and Aquaculture Adaptation Plan	0	

*Number of times the text referred to local governments
**Energy Climate change adaptation plan is not yet developed

Table 21: Specific line of action according to sectoral plans

Sectoral Plan*	Measure	Action
Cities	Promote green infrastructure projects in cities	Promote intersectoral coordination instances for the development of strategic green infrastructure plans, in line with existing and investment plans.
	Reduce energy consumption in public spaces	It raises the replacement of public lights at the country level, changing old devices for LED technology, involving savings in energy use. For 4 years, with fractions equal per year, municipalities will compete for technological replacement of luminaires for led technology
	Promote the efficient use of water resources in public spaces	Study the supply of water for irrigation of parks and green areas, and alternative sources to drinking water, seeking to guarantee its supply through redundancy of these sources
	Strengthen the development of municipal capacities for adaptation to climate change	Awareness of relevant actors at the local level in the face of climate change.
		Training of relevant actors at the local level in the face of climate change, through the b-learning course on management of the Climate Change at the Local Level
		Characterization of the main climatic threats from a local perspective.
		Preparation of Climate Change Action Plans that consolidate the local strategy for its gradual implementation according to prioritization and viability.
	Promote international cooperation relationships to strengthen adaptive capacity climate in cities	Develop specific projects to increase the ability to adapt to climate change with international support
		Participate in international collaboration networks related to climate change in cities
		Disseminate and deliver technical assistance on specific experiences of climate change in cities at an international level
	Generation of public-private partnerships for cooperation and action to face of change climate	Generate associations, alliances, and agreements collaboration for the implementation of the actions and measures of the Climate Change Adaptation and Action Plans
Biodiversity	Support for Public Policies to combat desertification	Incorporation of the theme of desertification in regional governments and local governments based on strategies and plans to combat desertification.
	Community management plans for sustainable development in selected municipalities	develop community plans for the sustainable development of the territory, considering the scenarios of climate change and its possible impacts on ecosystems and biodiversity on a local scale
	Design and implementation of a Conservation Landscape in the Commune of Alhué, Metropolitan region	Design and implementation of biological corridors between protected areas and management of buffer zones and Conservation Landscapes (green infrastructure)

* Adapted from Plan Sectorial Biodiversidad (2014) and Ciudades, Ministerio de Medio Ambiente (2018)

Table 22: Information from municipalities under sectoral policy guidelines

Measure	Examples
Promote green infrastructure projects in cities	"(…) environmental criteria have been incorporated into investment initiatives. For example, the implementation of green roofs in an educational establishment, Salvador Allende, august 2011" (Municipality El Bosque, 2021)
Reduce energy consumption in public spaces	"Solar Neighborhoods" (Municipality Colina, 2021) "Implementation of thermos in the offices of the municipality. The program was implemented with the aim of reducing electricity consumption in municipal offices to adapt to a scenario of energy shortages" (Municipality La Granja, 2021) "Replacement of luminaires to Led" (Municipality El La Cisterna, 2021) "community energy sovereignty program, including projects such as installation of solar panels, popular energy, free customer rate transfer of the consistorial building" (Municipality Recoleta, 2021)
Promote the efficient use of water resources in public spaces	"One of the successful initiatives is the Local Water Strategy (EHL), a municipal management tool that was born as an initiative of diagnosis, planning and cultural reflection on water. Taking into consideration the Chilean reality, context of scarcity and the effects derived from climate change. This instrument proposes a roadmap for taking actions in the short, as well as in the medium and long term. In this way, the Municipality of Providencia plans to advance towards a sustainable use of water, sensitizing and involving all sectors of the citizenry in the commune. The pillars of this strategy are: 1. Water Safety 2. Irrigation management 3.Water Culture 4.Water Governance Among the most successful concrete actions, the following stand out: 1. Water traps veiling's: the sidewalks with slits were redesigned to prevent rainwater from running through the streets and ending up in drains 2. Veredores bylaw: the ordinance will be modified to replace grass, which has a high-water consumption, with a list of plants and ground covers that resist prolonged droughts. 3.Automation of irrigation: with humidity sensors and specialized software 4. Tree renewal: 4,000 trees have already been planted in three years and this will be increased with species adapted to a semi-desert climate 5. Enlarge tree cups: "It doesn't make sense to have 1x1 m cups," says the plan document. Low-rise plant species will be planted where there are tiles" (Municipality Providencia, 2021)
Strengthen the development of municipal capacities for adaptation to climate change	"Participation in workshops, diplomats and conversations" (Municipality Las Condes, 2021) The Municipalities that have developed Adaptation Plans to climate change are those that have a climate profile, their impacts and vulnerabilities identified and of public access (Calera de Tango, Colina, Independencia, Lampa, La Pintana, La Reina, Macul Maipú, Peñalolén, Providencia, Quilicura, Renca, Santiago, Talagante, Vitacura). There are plans that date from 2015 to 2018 and 2019. However, none of these have updated their plans, so it is difficult to know which is the level of progress.
Promote international cooperation relationships to strengthen adaptive capacity climate in cities	The Chilean Network of Municipalities of Climate Change and Adapt-Chile, a non-profit organization, together with financing from the European Union, develop in Chile the adaptation plans to climate change as well as the development of local energy strategies and communication strategies of climate change, with the aim of increasing the capacities and abilities of local governments to adapt to climate change.
Generation of public-private partnerships for cooperation and action to face of change climate	The Public-private Regional Committee of Climate Change (CORECC) is constituted by the Regional Ministerial Secretary (SEREMIs) of various Ministries with competences in climate change, the Regional Sustainability and Climate Change Agency and representatives of Municipalities, Academia, Civil Society, and the Private Sector, depending on the particularities of each Region. The CORECC articulate that the municipalities of the Metropolitan Region received support and provide their experience to international associations, such as C40 and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Global Covenant of Mayors for Climate and Energy, Carbon Disclosure Project (CDP), among others.
Support for public policies to combat desertification	The different associations in which certain municipalities participate, help with desertification issues. The municipalities that belong to the Network of Municipalities of Climate Change, receive capacities and guidelines to identify climatic threats, such as droughts and work on lines of action to combat this problem. In the same way, the Association of Municipalities of Chile (AMUCH), has prepared two documents, with the support of

	international organizations, on how to face water scarcity at the local level, such as drought management. On the other hand, the Climate Change Law that is being processed in the Senate, considers the drought within its national, sectoral, and local guidelines. Within the local guidelines, the development of strategic plans in basins is determined "Specific measures to face the adverse effects derived from climate change, such as droughts, floods and loss of water quality; "
Community management plans for sustainable development in selected municipalities	"In January 2020, Law No. 20,202 was approved, which modifies various legal bodies with the aim of protecting urban wetlands, known as the Urban Wetlands Law. Considering the above, the Sustainability Directorate prepared a wetland cadaster of the commune, identifying more than 700 wetlands, of which approximately 70 are located in the urban area. Given this and given the importance of these ecosystems to combat climate change, work is being developed to ensure the protection of wetlands, having submitted the request for the declaration of 5 wetlands: 3 presented by the municipality and 2 presented by official letter of the Ministry of the Environment. This resulted in the first urban wetlands declared at the national level to be the following wetlands located in the commune: Tranque la Dehesa and Embalse Larraín. In this sense, work continues on submitting new applications for the declaration of wetlands and preparing a tender in order to characterize or later restore the ecosystems of urban wetlands, and a local ordinance in this regard." (Municipality Lo Barnechea, 2021)
Design and implementation of a conservation landscape in the commune of Alhué, metropolitan region	Due to the enormous importance of the protection of this area, various projects have been developed. The Municipality of Alhué developed, through the Commune Development Plan (PLADECO), the "Alhué, Conservation Landscape" Program, a strategy for the care of the natural, cultural and social landscape of the commune. Furher, to conserve the biodiversity of the natural and cultural landscape, other project such as the Biodiversity Conservation Program of the Altos de Cantillana Mountain Range financed by the Fund for the Global Environment Facility (GEF), the United Nations Development Program (UNDP), the Government of Chile and the Altos de Cantillana Foundation, whose objective is to give value to the endemic biodiversity of the cordon.

Political short-termism

Regarding, *Political short-termism* it was perceived by 91% of the respondents as a barrier to the implementation of climate adaptation measures, information which is to be expected since municipal governments in Chile last 4 years, so it is reasonable that for local governments it's not a factor that can be considered a driver for implementing climate projects, considering that in Chile on average projects take three years and four months to process in terms of environmental and sectoral issues (Ministry Economics, 2020). In the case of this variable, as mentioned before, by law all Mayor government periods last the same (4 years), so this variable would be present in all municipalities equally, which would be equivalent to 1, therefore it will be omitted of the analysis since it does not affect made any difference.

Annex 4: Sector classification under RedMuniCC guidelines

Water Develop the capacity of municipalities to ex ercise sustainable and territorial water management, promoting universal water efficiency and security	● Rural Drinking Water Maintenance Plan (APR) ● Community workshops on efficient water use ● Water efficiency program in municipal facilities ● Promotion of technical irrigation for agricultural production ● Maintenance of green areas with water efficiency criteria ● Supply of drinking water to rural areas through cistern trucks ● Installation of infrastructure for the accumulation of water or the mitigation of floods ● Irrigation water treatment plant with phytodepuration technology ● Study of the communal water situation ● Water use control system in school establishments
Energy Establish a comprehensive energy plan with a view to sustainable development of the communal territory	● Preparation and execution of Local Energy Strategy ● Solar heaters for ACS of educational establishments ● Replacement of public luminaires by LED technology ● Energy efficiency program in municipal facilities ● Measurement of carbon footprint in public buildings ● Measurement of carbon footprint of activities and / or local production processes ● Trainings on energy efficiency at the community and municipal level ● Solar water pumping for the agricultural or rural sector ● Training course on non-conventional renewable energies skills ● Energy efficiency criteria in public purchases and tenders
Ecosystems Promotion, recovery, conservation and sustainable use of ecosystems by integrating it transversally into municipal planning and management	● Community sponsorship program for native species ● Wilderness protection plan ● Arborization project in passages and avenues ● Construction of green areas with native and / or xerophytic vegetation ● Land registry of urban trees ● Signs to identify plant species in squares and parks ● Project for the installation of nesting houses in squares and parks ● Forest and agricultural fire reduction program ● Promotion of good agricultural practices ● Construction of educational trails in hills
Health Generate actions aimed at improving the prevention, promotion, response, and health care of the population in the face of the local effects of climate change	● Preventive education for the community ● Self-care workshops in public services and schools ● Studies to identify diseases associated with climate change ● Control and mitigation of disease vectors ● Training of primary health officials on the impacts of climate change ● Seasonal disease prevention campaigns ● Support network in mental health in the face of extreme events impacts ● Air quality inspection programs ● Control of discharges into irrigation water ● Inspection and supervision of economic activities
Waste management Develop a comprehensive waste management plan for the commune Support for the management of grassroots recyclers	● Composting and vermiculture plant ● Training on responsible consumption and comprehensive waste management ● Reduction and composting of waste from pruning urban trees ● Recycling plan in public facilities ● Installation of clean points ● Recovery of electronic waste and disposal in authorized places ● Campaign to reduce the use of plastic bags in commerce ● Management plan for waste produced in fishing operations ● Oil collection program from establishments and fast food carts ● Training in law enforcement REP 20.920
Transport and mobility Promote efficient and sustainable transport systems at the communal and intercommunal level	● Improvement of pedestrian paths ● Construction of bicycle lanes ● Low emission municipal vehicle fleet ● Public bicycle service ● Network of public bicycle racks ● Construction of alternative roads to reduce traffic congestion ● Exclusive routes for public transport ● Increase and maintenance of traffic signs ● Community awareness campaigns on efficient transportation ● Promotion of emissions compensation through reforestation
Culture and identity	● Program for the recovery of public spaces with and for the community ● Installation of educational modules on environment and climate change in squares and parks

Strengthen municipal management in education for sustainable development and work in coordination with indigenous peoples at the local level	● Promotion of the participation of the indigenous population in territorial planning ● Formation of territorial working groups ● Sustainable neighborhoods program ● Incorporation of sustainable development issues in PADEM (Annual Municipal Education Plan) ● Formation of community networks linked to sustainable development ● Promotion and development of community gardens ● Program for the protection of urban heritage ● Promotion of citizen participation in projects submitted to the SEIA (Environmental Impact Evaluation System)
Critical infrastructure Incorporate climate change criteria in territorial planning and construction of municipal infrastructure	● Registry of telephone and radio antennas ● Installation of energy infrastructure resilient to extreme events ● Inclusion of climate change criteria in territorial planning instruments ● Critical infrastructure protection protocols against extreme events ● Assessment of the state of the emergency services infrastructure ● Work tables with representatives of the supply of basic services ● Supervision of the state of electrical networks and drinking water ● Main road resurfacing projects ● Inclusive criteria in the construction of squares and parks ● Post-disaster community critical infrastructure assessment
Disaster risk management Develop a Comprehensive Risk Management Plan at the local level with concrete actions to reduce risk and vulnerability, increasing adaptive capacity	● Develop a comprehensive risk management plan at the local level ● Cleaning and repair program for water chambers and pavement ● Formation of a community support network in the event of extreme events ● Municipal training courses in risk management ● Periodic review of health care services infrastructure ● Risk construction considerations in territorial planning ● Contingency plans for sources of polluting materials ● Construction of a community risk map ● Encouragement for the preparation and proper use of emergency kits at the household level ● Capacity building on emergency management in social organizations

Annex 5: QCA Calibration process

In this procedure the variables were calibrate into crisp and fuzzy sets depending on the information that was on the Excel data base.
Under this premises, the primary data of the questionnaire that was already complemented with secondary data and coded went through a second analysis and coding.

Variables originating from a Yes / No answers were coded as crisp variables, which means Yes=1 No=0, details in *Table 23:*

Table 23: Crisp Variables calibration

Crisp Variables	**Criteria**
Development of Climate Adaptation Plan (CAPL)	Variable was coded with 1 if the local authority has a CAPL and 0 if they don't. Source: Survey
Political Stability (STAB)	To analyze political stability, what was done was to look at the government coalitions of the last 3 periods of the mayoral period, that is, of the last 12 years. Recent elections were not taken part of the study since what its being evaluated takes information from past government periods and the new commanders recently assumed (June 28, 2021). So, if the last periods were under the same political color, this information was taken as an indicator of stability, assigning a 1 to each case study; otherwise, it was evaluated with a 0. Source: Public information
Political cooperation through subsidies and/or programs (COOP)	Variable was coded with 1 if the local authority received subsidies or programs for developing climate adaptation initiatives and 0 if they don't. Source: Survey
Participation in Climate Change Networks (NETW)	If the municipality participate in climate change or sustainability association was coded with 1, otherwise with 0. Source: Survey
Trainings on Climate Change (TRAIN)	If the municipality imparted or received trainings or guidance related climate change the coding was 1, if the answer was negative, then 0. Source: Survey
Implementation of climate adaptation initiatives (ICCAI)	In the questionnaire was asked to give a successful example of ICCAI. Further to complement that answer what was done was to evaluate 77 documents which contained information on programs, projects and initiatives related to adaptation to climate change. If municipalities had implemented ICCAI=1 otherwise ICCAI=0. Source: Survey and public information

For the variables that are not dichotomous, a fuzzy coding was used (*Table 24*), and it was seen case by case how to determine the membership following a direct calibration model, proposed by Ragin (2008), which relies on a standard log odds model and focuses on three qualitative anchors (full membership; non membership and the cross over point). By using a logistic function, as Ragin mentions (pp. 185, 2008) "mathematically incapable of producing set membership scores of exactly 1.0 or 0.0. These two membership scores would correspond to positive and negative infinity, respectively, for the predicted log of the odds. Instead, scores that are 0.95 or greater may be interpreted as full membership in the target set, and scores that are 0.05 or less may be interpreted as full non-membership.". Taking this, is that the thresholds were defined as follows full membership (fuzzy score = 0.95), full nonmembership (fuzzy score = 0.05), and the cross-over point (fuzzy score = 0.5). The cross-over point is also known as indifference point, thus is the point where not enough information is available to define whether a case should be considered more a member or a non-member of the set (Schneider&Wageman, 2012).

Table 24: Fuzzy Variable Calibration

Fuzzy Variables	**Criteria**
Political Commitment (COMM)	Political commitment was evaluated by asking 3 questions to municipalities regarding the prioritization of climate change. They should respond 1. if this topic would be considered within the 10 municipal strategic pillars 2. if this topic would be considered within the 5 municipal strategic pillars and 3. If they would prioritize climate change within its 3 main strategic pillars. The summary of answers was collected and coded in a fuzzy scale of: 0=0,05 → non-membership thus municipalities are not interested in prioritized climate change. The sum of their answers was 0. 1=0,5 → cross-over point. Municipalities consider climate change within the first 10 topics to prioritize, but there are some that have implemented adaptation actions while other haven´t which makes difficult to decide if they are more in than out of the set. 3=0,95 → full membership. Municipalities consider climate change within the three topics. Source: Survey
Supportive Legislation/Regulation (SLR)	The analysis considers three questions from the questionnaire: “Does your municipality have a policy of climate change?”,” Is your municipality aligned to the national climate change strategy?” and “Is climate change adaptation integrate into other policies among other departments of the municipality?” The answers (Yes) were count and coded under: 0=0,05 → non-membership, when municipalities answer negative to every question. 1=0,5 → cross over point, when municipalities mention to be aligned to national climate change strategy, but the rest of the responses are negative so is questionable the degree of membership regarding SLR.

	3=0,95→ Full membership - the answer of three questions is positive. Source: Survey
Specific department of climate change/sustainability (DEP)	This variable was defined with the response of the question "Does you municipality have a specific department related to sustainability or climate change?" and complemented with information about the type of department it was i.e., different scores were given if it was a Directorate (2) or a sub-department (1). Then with this information the variable was coded into a fuzzy variable taken the values of 0,05= non-membership-no specific department 0,5= 0,5 → the point of ambiguity was defined at 0.5 since the other values that this variable can take is 1 (sub-department) or 2 (directorate – full-membership) and having a sub-department means being more in than out of the set, so this number should be above from the point of ambiguity of 0.5 2= 0,95; full membership, having a specific directorate Source: Survey and Public Information
Financial resources (FR)	The information used in this regard was the categorization of municipalities according to the rank of Mayor, a public Chilean categorization. This procedure is carried out through the categorization of the country's municipalities according to their income and inhabitants. This classification ranges from 1-4, where 4 are the municipalities with more resources. According to these values, the variable was calibrated as follows: 1=0,05 non membership thus not enough resources– 2.5=0,5 cross over point, municipalities classify with higher that 2.5, this mean, 3 and 4 are more in than out of the set 4=0,95 full membership – municipalities with categorization 4. Source: Public Information
Staff working directly in climate change issues (STAFF)	Staff working directly in climate change issues can take the scores of 0, 1 or 2 by proceeding the answer of the survey "Total amount of functionaries working on climate change projects" and s complemented it with the information of the question "Specific department of climate change or sustainability". The previous process has been done, since having a specific area, influence in staff, in the sense that the workers are dedicated specific on sustainability and climate change, while in the other cases, perhaps the same employee is working not only in jobs related to this issue, but also making other staff. With this information, this variable was coded under a fuzzy scale being 0,05=no membership -no staff.

	0,5 = 0,5 cross over point, thus variables with scores of 1 and 2 are more in than out of the set 0,95=2 full membership, when there is staff and a specific department Source: Survey

Details of the variables before and after calibration, can be observed in detail in Table 25 & Table 26.

Table 25: Variables before calibration

MUNICIPALITY NAME	ICCAI	CAPL	STAB	COOP	COMM	SLR	NETW	TRAIN	DEP	EFR	STAFF
SANTIAGO	1	1	1	1	3	2	1	11	1	4	1
CERRILLOS	0	0	1	0	2	0	0	0	0	2	0
CERRO NAVIA	1	0	1	0	3	1	0	101	1	3	1
EL BOSQUE	1	0	1	0	2	2	0	0	0	3	1
ESTACIÓN CENTRAL	0	0	1	0	1	0	0	0	0	2	0
HUECHURABA	1	0	1	0	3	3	1	1	0	3	1
LA CISTERNA	1	0	1	0	1	0	1	0	0	2	0
LA FLORIDA	0	0	1	0	2	1	1	1	0	4	1
LA GRANJA	1	0	1	0	2	1	1	0	0	2	1
LA PINTANA	1	1	1	0	3	3	0	0	0	3	1
LAS CONDES	1	0	1	0	1	1	0	0	0	4	1
LO BARNECHEA	1	0	1	1	3	3	0	3	2	4	2
LO ESPEJO	0	0	1	0	3	0	0	0	0	2	0
LO PRADO	1	0	1	0	2	2	1	2	0	2	1
MAIPÚ	1	1	0	0	3	3	1	85	1	4	1
ÑUÑOA	0	0	1	0	2	1	0	0	0	3	0
PEDRO AGUIRRE CERDA	0	0	1	0	0	0	0	0	0	2	0
PEÑALOLÉN	1	1	1	1	3	3	1	101	1	4	1
PROVIDENCIA	1	1	1	1	3	3	1	1	1	4	1
PUDAHUEL	1	0	1	0	3	2	0	55	1	3	1
QUINTA NORMAL	0	0	1	0	1	0	0	0	0	2	0
RECOLETA	1	0	1	0	3	3	1	11	0	3	1
RENCA	1	1	1	1	2	3	1	1	1	3	1
SAN JOAQUÍN	1	0	1	0	2	1	0	0	0	2	0
SAN MIGUEL	1	0	0	0	3	3	0	0	0	2	1
SAN RAMÓN	1	0	1	0	2	0	0	0	0	2	0
VITACURA	1	1	1	0	2	2	1	1	2	4	2
PUENTE ALTO	1	0	1	1	3	3	1	1	1	4	1
PIRQUE	0	0	1	0	1	2	0	0	0	1	0
SAN JOSÉ DE MAIPO	1	0	1	0	0	0	0	0	0	1	1
COLINA	1	1	1	1	3	2	1	3	0	3	1
SAN BERNARDO	0	0	1	0	3	0	0	0	0	4	0
BUIN	0	0	1	0	3	1	0	0	0	2	0
PAINE	1	0	1	1	3	2	1	11	0	2	1
ALHUÉ	1	0	1	1	1	0	0	0	0	1	0
CURACAVÍ	1	0	1	0	3	1	1	0	0	1	0
MARÍA PINTO	1	0	1	1	3	3	1	13	0	1	1
TALAGANTE	1	1	1	1	3	2	1	0	0	2	1
ISLA DE MAIPO	0	0	1	0	2	0	0	0	0	1	0
PADRE HURTADO	1	0	1	0	3	2	0	0	0	2	0
PEÑAFLOR	1	0	1	0	0	0	1	2	1	2	1

Table 26: Variables after calibration

MUNICIPALITY NAME	ICCAI	CAPL	STAB	COOP	COMM	SLR	NETW	TRAIN	DEP	FR	STAFF
SANTIAGO	1	1	1	1	0,95	0,82	1	1	0,73	0,95	0,73
CERRILLOS	0	0	1	0	0,82	0,05	0	0	0,05	0,27	0,05
CERRO NAVIA	1	0	1	0	0,95	0,5	0	1	0,73	0,73	0,73
EL BOSQUE	1	0	1	0	0,82	0,82	0	0	0,05	0,73	0,73
ESTACIÓN CENTRAL	0	0	1	0	0,5	0,05	0	0	0,05	0,27	0,05
HUECHURABA	1	0	1	0	0,95	0,95	1	1	0,05	0,73	0,73
LA CISTERNA	1	0	1	0	0,5	0,05	1	0	0,05	0,27	0,05
LA FLORIDA	0	0	1	0	0,82	0,5	1	1	0,05	0,95	0,73
LA GRANJA	1	0	1	0	0,82	0,5	1	0	0,05	0,27	0,73
LA PINTANA	1	1	1	0	0,95	0,95	0	0	0,05	0,73	0,73
LAS CONDES	1	0	1	0	0,5	0,5	0	0	0,05	0,95	0,73
LO BARNECHEA	1	0	1	1	0,95	0,95	0	1	0,95	0,95	0,95
LO ESPEJO	0	0	1	0	0,95	0,05	0	0	0,05	0,27	0,05
LO PRADO	1	0	1	0	0,82	0,82	1	1	0,05	0,27	0,73
MAIPÚ	1	1	0	0	0,95	0,95	1	1	0,73	0,95	0,73
ÑUÑOA	0	0	1	0	0,82	0,5	0	0	0,05	0,73	0,05
PEDRO AGUIRRE CERDA	0	0	1	0	0,05	0,05	0	0	0,05	0,27	0,05
PEÑALOLÉN	1	1	1	1	0,95	0,95	1	1	0,73	0,95	0,73
PROVIDENCIA	1	1	1	1	0,95	0,95	1	1	0,73	0,95	0,73
PUDAHUEL	1	0	1	0	0,95	0,82	0	1	0,73	0,73	0,73
QUINTA NORMAL	0	0	1	0	0,5	0,05	0	0	0,05	0,27	0,05
RECOLETA	1	0	1	0	0,95	0,95	1	1	0,05	0,73	0,73
RENCA	1	1	1	1	0,82	0,95	1	1	0,73	0,73	0,73
SAN JOAQUÍN	1	0	1	0	0,82	0,5	0	0	0,05	0,27	0,05
SAN MIGUEL	1	0	0	0	0,95	0,95	0	0	0,05	0,27	0,73
SAN RAMÓN	1	0	1	0	0,82	0,05	0	0	0,05	0,27	0,05
VITACURA	1	1	1	0	0,82	0,82	1	1	0,95	0,95	0,95
PUENTE ALTO	1	0	1	1	0,95	0,95	1	1	0,73	0,95	0,73
PIRQUE	0	0	1	0	0,5	0,82	0	0	0,05	0,05	0,05
SAN JOSÉ DE MAIPO	1	0	1	0	0,05	0,05	0	0	0,05	0,05	0,73
COLINA	1	1	1	1	0,95	0,82	1	1	0,05	0,73	0,73
SAN BERNARDO	0	0	1	0	0,95	0,05	0	0	0,05	0,95	0,05
BUIN	0	0	1	0	0,95	0,5	0	0	0,05	0,27	0,05
PAINE	1	0	1	1	0,95	0,82	1	1	0,05	0,27	0,73
ALHUÉ	1	0	1	1	0,5	0,05	0	0	0,05	0,05	0,05
CURACAVÍ	1	0	1	0	0,95	0,5	1	0	0,05	0,05	0,05
MARÍA PINTO	1	0	1	1	0,95	0,95	1	1	0,05	0,05	0,73
TALAGANTE	1	1	1	1	0,95	0,82	1	0	0,05	0,27	0,73
ISLA DE MAIPO	0	0	1	0	0,82	0,05	0	0	0,05	0,05	0,05
PADRE HURTADO	1	0	1	0	0,95	0,82	0	0	0,05	0,27	0,05
PEÑAFLOR	1	0	1	0	0,05	0,05	1	1	0,73	0,27	0,73

Institute for Housing and
Urban Development Studies of
Erasmus University Rotterdam