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**The Governance of Adaptation to Climate Change in
Medium-sized European Cities.: a comparative
assessment of Växjö (Sweden), Nijmegen (Netherlands),
Leuven (Belgium), Rouen (France) and San Sebastian
(Spain)**

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The Governance of Adaptation to Climate Change in
Medium-sized European Cities: *A comparative
assessment of Växjö (Sweden), Nijmegen (Netherlands),
Leuven (Belgium), Rouen (France) and San Sebastian
(Spain)*

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ABSTRACT

Significant climate changes are foreseen in the coming years alongside major impacts of frequent and extreme weather conditions affecting cities, residents, and urban infrastructure systems. In parallel, demographic changes and increased urbanization are anticipated given that most of the world's population is expected to be residing in cities in the following decades. Therefore, adapting urban areas remains an urgent matter as cities are susceptible and vulnerable to climate change on one hand, and are exposing a large and an increased number of dwellers to major impacts on the other hand.

This research focuses on medium-sized European cities, hosting millions of people and exposing them to the major impacts of global warming. These cities could be at disadvantage in comparison to larger cities given that they could have limited technical, financial, and human resources. However, they also present certain advantages as addressing the issue seems more manageable in limited geographical areas, in comparison to metropolitan areas. Additionally, small administrations benefit from straight and short lines of communication. The selected unit highlights the severity and magnitude of climate-related issues in urban areas and underlines the urgency to act. It also sheds light on the role of local governments and municipalities in addressing a topic of global relevance.

Experimenting locally with adaptation approaches could present both opportunities and challenges given that climate change is a global issue. Hence, questions are raised to deduce the way forward in the governance of climate change adaptation in medium-sized cities.

This study adds to the existing literature by underlining the impacts of climate change on urban systems in the selected mid-sized European cities. It also investigates the role of local municipalities and governments in developing and implementing environmental and adaptation action plans. For this purpose, a comparative case study approach is adopted, focusing on five medium-sized European cities: Växjö (Sweden), Nijmegen (the Netherlands), Leuven (Belgium), Rouen (France), and San Sebastian (Spain).

This approach sheds the light on various methods employed by local governments to understand impacts, develop corresponding strategies, mobilize actors, implement developed strategies, monitor, and evaluate adaptation progress, understand barriers to implementation and improve the governance system in place.

An urban climate adaptation governance index is developed allowing to assess whether governance efforts have contributed to ensuring the adaptability of mid-sized European city and increase their resilience to climate events. This index is applied to each of the selected case studies to quantify and benchmark their efforts against one another.

The results of the comparison of the selected mid-sized cities reveal the importance of the collaboration of local authorities with local experts and universities to bridge knowledge gaps in climate adaptation, map vulnerability, and raise public awareness. They also underline the importance of adopting a strategy of anticipation of risks and adaptation to climate change instead of taking reactive measures. The comparative analysis stresses the need to adopt a participatory governance approach, embrace opportunities, turn strategies into action plans and concrete measures, and experiment with small-scale initiatives. It also stresses the need for systemic changes as well as changes to the way mid-sized cities are designed and governed. The results introduce the importance of developing monitoring and evaluation systems as well as indicators dedicated to assessing adaptation efforts. Lastly, they underline the significance of reporting to the public on the progress of adaptation measures and developing a long-term vision as well as contingency plans to build preparedness and increase climate resilience.

Keywords: *Climate Change, Adaptation, Governance, Medium-sized Cities, Urban resilience.*

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I hope this thesis reaches a wide range of readers and key stakeholders leading the work on climate adaptation. And I hope it helps them address an issue of global relevance and increase urban resilience. With that being said, I hope you find pleasure in going through the research findings as much as I had the pleasure of working on this project.

List of abbreviations & acronyms

- **ADEME:** Agence de l'environnement et de la maîtrise de l'énergie (French environment and energy management agency)
- **ATP:** Adaptation Tipping Point
- **COP:** Conferences of Parties
- **CSO:** Civil Society Organisation
- **DATAR:** Délégation interministérielle à l'aménagement du territoire et à l'attractivité régionale (Interministerial Delegation for Regional Planning and Attractiveness – France)
- **DREAL:** Direction Régionale de l'Environnement, de l'Aménagement et du Logement (Regional Directorate for the Environment, Planning and Housing – France)
- **EC:** European Commission
- **EEA:** European Environment Agency
- **EGC:** European Green Capital (Award)
- **EU:** European Union
- **FNAU:** Fédération nationale des agences d'urbanisme (French National Federation of Urban Agencies)
- **GHG:** Greenhouse Gas
- **GIS:** Geographic Information System
- **ICCCAD:** International Centre for Climate Change and Development
- **ICLEI:** International Council for Local Environmental Initiatives
- **ICT:** Information and Communications Technology
- **IPCC:** Intergovernmental Panel on Climate Change
- **INSEE:** Institut National de la Statistique et des Etudes Economiques (French National Institut of Statistics and Economic Studies).
- **KNMI:** Koninklijk Nederlands Meteorologisch Instituut (The Royal Dutch Meteorological Institute)
- **M&E:** Monitoring and Evaluation
- **MIRA:** Milieurapport Vlaanderen (The Flemish Environmental Reporting Service – Belgium)
- **NAP:** National Adaptation Plan
- **NAS:** National Adaptation Strategy
- **NASA:** National Aeronautics and Space Administration (the USA)
- **NGO:** Non-Governmental Organization
- **nrg4SD:** Network of Regional Governments for Sustainable Development
- **PCAET:** Plan Climat Air Énergie Territorial (Climate-Air-Energy Territorial Plan – France)
- **PCS:** Plan Communal de Sauvegarde (Municipal Protection Plan – France)
- **PPRI:** Plan de Prévention des Risque Inondation, France (Flood Risk Prevention Plan)
- **RAS:** Regional Adaptation Strategy
- **RSA:** Risk- och sårbarhetsanalys (Risk and Vulnerability Analysis – Case of Växjö, Sweden)
- **SDG:** Sustainable Development Goal
- **SDAGE:** Schéma Directeur d'Aménagement et de Gestion des Eaux (Master Plan for Water Development and Management – France).
- **SGAR:** Secrétariat Général pour les Affaires Régionales (General Secretariat for Regional Affairs – France)
- **SMHI:** Swedish Meteorological and Hydrological Institute
- **SRCAE:** Schéma Régional Climat Air Énergie (Regional Climate-Air-Energy Scheme – France)
- **UNCDF:** United Nations Capital Development Fund

- **UNCED:** United Nations Conference on Environment and Development
- **UNDP:** United Nations Development Program
- **UNEP:** United Nations Environment Program
- **UNFCCC:** United Nations Framework Convention on Climate Change
- **VAP:** Vlaams adaptatieplan (Flemish adaptation plan – Belgium)
- **VKP:** Vlaams Klimaatbeleidsplan (Flemish climate policy plan – Belgium)
- **VMM:** Vlaamse Milieumaatschappij (Flemish Environment Agency – Belgium)
- **VRGZ:** Veiligheidsregio Gelderland-Zuid (Gelderland-South region safety region¹ – the Netherlands)
- **VTFA:** Vlaamse Task Force Adaptatie (Flemish adaptation task force – Belgium)

¹ In the Netherlands, a safety region is a partnership of the emergency services on the basis of the Joint Regulations Act and the Safety Regions Act, for the purpose of physical safety.

CHAPTER 1: INTRODUCTION

1.1 Background Information

Climate change is a topic of global relevance that has been preoccupying researchers, scientists, experts as well as policymakers for decades now. According to the US National Aeronautics and Space Administration (NASA, 2021) and as communicated on its official website, variation in climate conditions is not new to planet earth as this globe has witnessed various cycles of glacial advance and retreat throughout history. However, the current global warming is of particular concern as the changes in climate condition is largely driven by human-made emissions (NASA, 2021; IPCC, 2021).

The series of reports drafted by the Intergovernmental Panel on Climate Change (IPCC) asserted that this global phenomenon is already affecting weather extremes in every region across the globe such as the flooding of coastlines, changes in precipitation patterns, stretched period of heatwaves, and the intensification of droughts and other extreme weather events (IPCC, 2013, 2018, 2021). These meteorological events could have catastrophic consequences not only on agriculture, wildlife, and biodiversity, but also on economies, societies, cities, and entire nations (NASA, 2021).

More and more people around the world are becoming aware of the seriousness of this issue as major impacts have been coming to the surface such as extreme weather conditions and new temperature records in different countries and regions (Fagan & Huang, 2019). Various events, such as the 2019 Amazonian wildfires and the July 2019 European heatwave (which set new temperature records), were 'eye openers' for people across the globe on the importance of addressing the issue of climate change and building climate resilience. Additionally, the summer floods that have occurred in western Europe in July 2021, impacting majorly the UK, Germany, Belgium, and Switzerland, and leading to the death of over 190 people emphasized the damage that could occur due to climate change even in some of the most developed countries which have invested in flood forecasting and preparation (Cornwall, 2021).

Globally, the idea of addressing environmental issues and ensuring sustainable development has reached a climax since the 1990s (Aykut & Dahan, 2014). The topic has gained special attention from various parties calling for global action, including different governmental levels and representatives of various sectors, organizations, policymakers, enterprises, researchers, and scientists (Aykut & Dahan, 2014).

The series of reports drafted by the IPCC as well as other scientific researchers, summarizing facts on the topic, were crucial to provoke international interest to address the problem (Martin, 2015). These reports highlighted how human activity is one of the main causes of global warming. The contribution of working group I to the 5th assessment report of the IPCC (2013) presented that, since the industrial revolution, the concentration of greenhouse gas emissions (GHG) in the atmosphere, because of the high reliance on fossil fuels, has caused the average global temperature to rise by 1 °C. It asserted that if GHG emissions continue at current rates or higher the temperature rise could reach 2 to 5 °C above industrial levels by 2100 causing serious impacts and environmental catastrophes (IPCC, 2013). In October 2018, a special report released by the

IPCC accentuated the urgency of addressing the global issue of climate change and keeping the global temperature below 1.5 °C instead of 2.0 °C above the pre-industrial level. It also stressed that if GHG emissions continue at the current rate, it is predicted that the earth's temperature will rise by 1.5°C between 2030 and 2052 (IPCC, 2018). A 6th assessment report of the IPCC released in August 2021 affirmed that evidence of observed changes in extreme weather conditions has strengthened since the release of the 5th assessment report and underlined the importance of limiting and planning for future climate change. Following these reports, and as the effects of climate change have been coming to light, a sense of urgency to act has emerged. Not to mention, the warming of the earth is considered a real threat as it is happening too rapidly for people to adapt. On its online platform, NASA communicated that “nineteen of the 20 warmest years on record have occurred since 2001” (NASA, 2021).

196 parties acknowledged the role of human in altering climate conditions and have agreed to limit their emissions and adapt to climate change upon signing the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED), commonly known as the 'Rio Summit' or the 'Earth Summit'. The UNCED led to great achievements such as the 'Agenda 21' program calling for action to ensure sustainable development in the 21st century. It also resulted in the assertion of the principles of forest management, a convention on biological diversity, and the creation of a commission for sustainable development. Not to mention, it paved the way for the Kyoto Protocol which was adopted in 1997 as a treaty to reduce GHG emissions and became effective in 2005. During the United Nations Climate Change Conference in 2010, an agreement was produced to limit global warming to 2.0 °C (3.6 °F) above the pre-industrial level. Five years later, the momentum Paris agreement brought 195 nations into a common responsibility to ensure a low-carbon, sustainable and resilient future. This agreement (UNFCCC, 2015) set the goal to reinforce the global action to the risks of climate change through not only acting to limit GHG emissions but also ensuring climate-resilient approaches and enhancing the capability to adapt to the unfavorable effects of climate change (Aykut & Dahan, 2014).

Reducing emissions is crucial to address the issue of climate change and limit the increase of global temperature. However, in its updated new EU Strategy on climate adaptation, the European Commission (2021) underlined that taking action to adapt the earth to changes of climate is inevitable. Especially that researchers have shown that even if emissions were to stop today, the planet will keep on warming and the world will still have to deal with the consequences of climate change for hundreds of years (Frölicher, Winton, & Sarmiento, 2013).

This thesis is focused on Europe, in particular, given that addressing the global issue of Climate Change is among the priorities of the European Union (EU). State members have agreed on reducing GHG emissions and increasing energy efficiency. The European Commission (EC) also has adopted an adaptation strategy on an EU level and incited its member states to develop national plans to manage the unavoidable impacts of climate change.

1.2 Problem Statement

Throughout the years more attention has been given to mitigation than to adaptation measures. Actions on a global and a European scale have been primarily focused on reducing GHG emissions

rather than adapting countries and regions and increasing their resilience to changes in climate. “Whilst many cities in Europe are already working on mitigating the effects of climate change, adapting to climate risks is still a novel challenge for many of them” (Lukat et al., 2016).

Despite global and transnational efforts to take climate actions, the issue is exacerbating. A range of various extreme weather conditions has manifested and is likely to increase in the light of global warming, directly impacting countries, regions, and cities and have further socio-economic ramifications on their inhabitants (NASA, 2021). In its global risk report for the year 2020, the World Economic Forum classified ‘climate action failure’, ‘biodiversity loss’, ‘extreme weather’ and ‘water crisis’ respectively as the 1st, 3rd, 4th, and 5th global threats out of “Top 5 Global Risks in terms of Impact” (World Economic Forum, 2020).

The IPCC (2021), in its 6th assessment report, affirmed that “with global warming, urban areas and cities will be affected by more frequent occurrence of extreme climate events”. An associate at the International Centre for Climate Change and Development (ICCCAD) (interview, 2018) elucidated that, generally, cities are vulnerable to this global issue, since, historically, human settlements which grew into the cities we know today, were established at the proximity of surface-waters (rivers, seas, oceans, etc.) to allow for trading, transportation, and connectivity. This geographical location puts them at great risk of rising sea levels, flooding, severe rainfalls, and frequent storms. Moreover, cities are places of concentration of physical and social infrastructure systems which makes them more exposed to natural and environmental hazards and therefore more vulnerable (Hallegatte & Corfee-Morlot, 2010; Associate at the ICCCAD, interview, 2018). The situation is particularly alarming as, according to a data sheet developed by the Population Reference Bureau (2016), approximately 60% of people are living in cities today and this percentage is expected to increase to at least 70% of the world population by 2050.

Extreme weather conditions stirred by climate change are likely to have a series of compounding consequences. These weather events could disrupt day-to-day activity and have further economic ramifications. Examples are seen every year with urban hubs drowning following heavy rainfalls or rivers’ flooding, destructing houses, damaging highways, cutting off roads, and devastating entire cities. For instance, according to the press, Hurricane Harvey which hit Texas in 2017 affected 13 million people and have caused 125 billion US dollars in damages (World Vision Staff, 2018).

The research focuses on medium-sized cities in Europe, in particular, given that according to a series of research produced by the Directorate-General for Regional and Urban Policy at the European Commission (Dijkstra & Poelman, 2012), the largest part of this continent’s urban population lives in cities of this scale. Not to mention, various researchers have underlined that the mid-sized cities -i.e., cities with a population between 50,000 and 250,000 inhabitants²- present an underdeveloped area of study. Giffinger et al. (2007) stated that medium-sized cities have been relatively neglected by both related international organizations and researchers, probably due to the focus and interest of urban research on large cities or ‘global’ metropolises. Živanović et al. (2014) presented that “statistical and other information materials related to medium-sized cities available at a European level are rather limited and lacking conceptual comparability”. A European Environment Agency (EEA) report on urban adaptation to climate

² As defined by the Covenant of Mayor’s classification (the criteria are discussed further in section 3.2.1)

change in Europe (EEA, 2016a) underlined that small and medium-sized cities are often linked to urban networks with various metropolitan areas or major urban centers, yet they have different resources for tackling the challenges and face different conditions.

Mid-sized cities are seen as sensitive and vulnerable to climate change as they expose millions of people and a great number of infrastructures to the impacts of climate change. Further factors could maximize the susceptibility of these cities like their location and rapid urbanization. Medium-sized cities are likely to find themselves at disadvantage in comparison to larger cities, as they could have limited technical and financial resources as well as aging or failing urban infrastructure systems which affect their resilience (Mungo, 2017; Filho et al., 2019). Smart Cities Consulting GmbH (2018) stated on its online platform that “many big cities like Berlin, London, or Vienna are already set up with a climate change adaptation strategy, but many small and medium-sized cities lack basic data or even awareness for that problem”. According to Hildreth (2007), the focus of various actors on metropolitan areas and big cities could be linked to the fact that large cities present themselves as centers for services and information and are often perceived as an opportunity for developed countries to keep ahead in a growingly competitive global economy.

In a discussion note developed by the United Nations Development Program (UNDP), Capital Development Fund (UNCDF) & the Environment Program (UNEP) in 2010, it has been stated that local governments have an important role in responding to the impacts of climate change as these are highly localized affairs and necessary responses are often location-specific and time-specific. However, given that climate change is an issue of global relevance, local authorities in mid-sized cities could face challenges in addressing the problem. They could lack the motivation, the resources, or the knowledge to take climate actions. “The enormity and complexity of weather-related disaster preparedness limit the capacity of any individual local government to cope with these phenomena” (McArdle, 2014).

For these reasons, close attention needs to be paid to the climate adaptation of medium-sized cities. This research project, therefore, elaborates on the topic of the governance of climate change adaptation in medium-sized European cities.

1.3 Research Objective and Questions

This thesis has a twofold objective. Firstly, it aims on emphasizing the importance of climate change adaptation at a local scale. Secondly, it aims at improving the knowledge on relations between adaptation governance systems and responses that can be examined and evaluated, and a range of climate impacts and vulnerability in different medium-sized cities in Europe.

To achieve the underlined objectives, the thesis addresses the main research question: Are the governance efforts of local authorities in mid-sized European cities contributing to increasing the adaptive capacity of the territory to climate events?

To answer this research question, sub-questions are addressed, on one hand, to determine the efforts of local governments in place to adapt to climate change, as well as the opportunities, and challenges encountered by local authorities in mid-sized European cities through the development and implementation of adaptation policies. On the other hand, to conclude by presenting preferred

adaptation governance approaches improving the adaptive capacity of mid-sized cities and increasing their climate resilience.

This thesis stresses the importance of climate governance and supposes that developing and implementing climate adaptation policies increase the resilience of a territory to climate events. It also supposes that the ability of cities to address climate issues is a factor of their scale, the governance system in place (i.e., centralized vs. decentralized governance) as well as the priorities and the motivation of local authorities.

These hypotheses are considered starting points for further investigation. The comparative case study approach adopted to answer the research questions would either confirm or dismiss these suggestions.

To meet the stated objective, answer the research questions and verify the hypotheses, this research project starts by investigating existing literature on the impacts of climate change, adaptation approaches and strategies, the governance of climate change as well as relevant support tools (chapter 2). This thesis then introduces the adopted methodology including the research framework, the strategy, limitations as well as data collection and analysis methods. As part of the methodology, an index is conceived and presented permitting to evaluate the efforts of local governments in adapting mid-cities cities in Europe to climate events to increase their resilience (chapter 3). Each of the selected case studies is then introduced with a detailing of the various adaptation responses in place to assessed impacts based on information retrieved from conducted interviews and a review of institutional structures, implemented policies as well as developed strategies to adapt the urban infrastructure to climate change. The presented primary and secondary data is employed to answer the proposed assessment questions which form the index quantifying the urban climate adaptation governance of each of the selected mid-sized cities (chapter 4). A comparative analysis follows the presentation of case studies contrasting the efforts of different medium-sized European cities to adapt to climate change (chapter 5). A feedback loop is then presented discussing the methodology and determining how the suggested urban climate adaptation governance index can be further improved based on the response of key city actors who tested this index as a self-assessment tool. Following this discussion, the thesis concludes on whether the existing governance systems in place allow to improve the adaptive capacity of cities in the light of climate change and presents recommendation for further research (chapter 6).

CHAPTER 2: LITERATURE REVIEW

The earth's climate is changing rapidly and will continue to change in the coming century making it challenging for governments to take appropriate climate actions and for societies and communities to adapt due to the high uncertainty associated with climate risks (Adger et al., 2003). Van der Gaast & Begg (2012) stated that this global phenomenon and "its accompanying consequences because of anthropogenic emissions of greenhouse gases (GHG) are among the most daunting environmental problems in the world today". Adger et al. (2003) indicated that climate change is conceivably the most obstinate threat to the global stability of the 21st century. Scientific researchers have foreseen that because of climate change extreme climate events are expected to increase in frequency and intensity in the coming years causing a broad range of impacts affecting various sectors and regions across the globe (Aykut & Dahan, 2014; Burch & Harris, 2014).

The U.S. Global Change Research Program (USGCRP, 2018) communicated on its online platform that climate change reveals itself differently in various regions across the world, some countries may experience hotter and shorter winters, while others could experience freezing and colder seasons. This was also underlined by the IPCC (2021) in its 6th assessment report which presented a synthesis of analysis of observed change in hot extremes, heavy precipitation, as well as agricultural and ecological drought in different regions of the world.

Extreme weather events will be more frequent and more intense causing serious damages to the environment and to the urban infrastructure (USGCRP, 2018). These events have further repercussions on the social and economic structure as climate change impacts important sectors such as energy, transportation, human health, water supply, agriculture, and food security as well as ecosystems and biodiversity (Van der Gaast & Begg, 2012).

While climate change has mostly negative consequences, in certain areas, opportunities may arise. For instance, the potential of hydropower or solar potential for energy production could increase, similarly, tourism could be boosted due to longer summer periods as highlighted in the figure developed by the European Environment Agency (EEA, 2017) on key observed and projected climate change and impacts in Europe (*figure 1*). Therefore, adapting to climate change is crucial, on one hand, to increase the resilience of regions and cities to climate change, and on the other, to take advantage of any opportunity that may arise due to shocks, stresses, or changes (Burch & Harris, 2014).

As this thesis is focused on the governance of climate change adaptation in European cities, this chapter starts by examining the observed and the projected impacts of climate change on this continent. It then explores the impacts of this phenomenon on medium-sized European cities. Literature reviews on the limitation and challenges of adaptation as well as drivers and opportunities are investigated. This chapter then elaborates on the governance of climate change adaptation and the role of non-state actors (i.e., city networks, online platforms, and civil society) in adapting cities and increasing their resilience to climate change. As climate adaptation is relatively a recent area of focus, the scoping did not exclusively focus on scientific journal articles but also included press releases as well as reports developed by the European Environment

Agency, Environmental NGOs, the World Bank as well as city networks and platforms addressing adaptation and urban climate resilience.

2.1 Impacts of Climate Change on Medium Sized European Cities

2.1.1 Impacts of Climate Change on Europe

“Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes” (IPCC, 2021). For decades, Europe has faced a series of unfortunate environmental events due to climate change such as extreme weather conditions, long heatwaves, heavy storms, and flooding. One of the most devastating weather events occurred in 2003 when most countries were impacted by a severe heatwave and extreme drought which have led to the death of more than 70,000 people in Europe (Robine et al., 2008). Many of the victims were vulnerable people such as the elderly, infants, and people with illnesses who were unable to endure this exceptional heat. This event also had negative impacts on the agricultural yields and on the energy sector (Robine et al., 2008). According to a UNEP-Environment Alert Bulletin on the Impacts of summer 2003 heatwave in Europe (UNEP, 2004), the total financial losses related to this heatwave are assessed to surpass 13 billion euros. In the summer of 2019, a heatwave comparable to the 2003 heatwave marked new record-breaking temperatures in various European countries (Xu et al. 2020). A BBC Press release (Siret, 2019) featured that this heatwave led to the perturbation of transportation systems, water shortages, forest fires, and the increase in death rates. Other weather-related events impacted Europe across the years such as the 2021 summer floods that have devastated parts of northern and central Europe resulting in widespread damage to agriculture and the infrastructure in the damaged area, power outages, forced evacuations, and over 190 deaths (Cornwall, 2021).

The 6th assessment report developed by the IPCC (2021) presented in its synthesis of analysis of observed change across the globe, that since the 1950s, Europe has observed an increase in hot extremes and an increase in heavy precipitation. Additionally, western and Central Europe has witnessed an increase in agricultural and ecological drought. However, in Northern and Eastern Europe there is a low agreement on whether agricultural and ecological drought has increased or decreased (IPCC, 2021).

As presented in the figure developed by the EEA (2017) on ‘key observed and projected climate change and impacts in Europe’ (*figure 1*), the effects of climate change vary across the continent as the latter extends over a large topographical area from the Arctic Ocean in the north to the Mediterranean and the Black seas in the south and from the Russian Federation in the east to Iceland in the west. The EEA (2017) has therefore classified various bio-geographical regions: The Arctic, the Atlantic, Coastal zones and regional seas, the Mediterranean, the Boreal, the Continental region, and Mountainous areas. Each of these zones has certain observed and anticipated impacts of climate change.

The Arctic region, marked in grey in figure 1, is according to the European Environment Agency, expected to deal with a temperature rise higher than the global average, a decrease in its ice coverage as well as threats to the livelihoods of ethnic people (EEA, 2017). These effects are starting to come to the surface. For instance, in February 2018, a press article (Braun, 2018) broadcasted that the temperatures in the Arctic marked 20 degrees higher than the usual to reach

6 degrees Celsius, while during the same period European cities witnessed freezing conditions and temperatures dropped to the lowest seen in centuries.

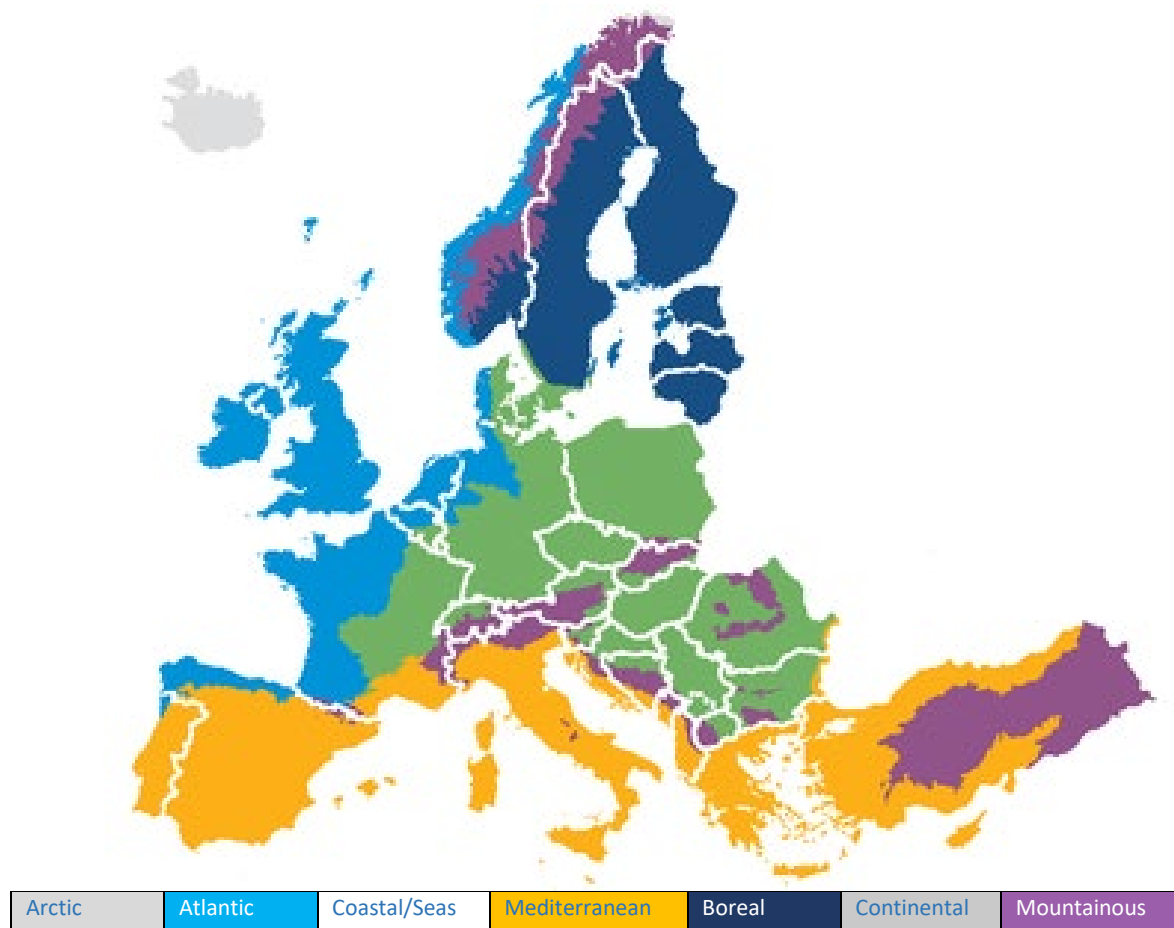


Figure 1 Key observed and projected climate change and impacts for the main regions in Europe. Source: EEA, 2017.

The Atlantic region, highlighted in vivid blue in figure 1, is according to the EEA (2017) at risk of flooding due to the projected increase in heavy rainfall events and the upsurge in river flows. It is also at risk of increased damages due to winter storms as well as an amplified susceptibility to climatic hazards (EEA, 2017). As a case in point, a report for the World Bank (2012) developed by the Potsdam Institute for Climate Impact Research and Climate Analytics highlighted that in 2000, Wales and England witnessed the wettest fall season since 1766, resulting in damages adding up to more than 1 billion pounds.

Climate change is also responsible for the rise of sea level, the increase in ocean acidity, and the rise of sea surface temperatures which impacts fisheries, marine species and increases the risk of waterborne viruses (EEA, 2017). As communicated on the NASA online platform (2021), globally, the sea level has risen by approximately 20 cm (8 inches) since the first reliable records began keeping track in 1880. Projections foresee another increase ranging between 30 cm and 240 cm by 2100 (NASA, 2021).

In addition to the rise of sea level, the Mediterranean region, marked in yellow in figure 1, is prone to an intensification of heat extremes which poses health risks and increases the mortality rate

from heatwaves as well as the risk of forest fires (EEA, 2017). It also could have negative impacts on summer tourism but could increase tourism potential in other seasons. High temperature increases the energy demand for cooling and could impact most economic sectors. Additionally, the Mediterranean region is prone to a decline in river flows, changes in precipitation patterns, and an increase in droughts risk which potentially leads to a decrease in crop yields and increases in water demand for agriculture (EEA, 2017). For instance, a press article (Hierro, 2015) alerted the public that Spain is at risk of facing a water crisis as in the last two decades, it has lost more than 20% of its fresh water and this amount is expecting to increase and reach 25% by 2021.

The European Environment Agency (2017) stated that in the Boreal region (*colored in navy blue in figure 1*), heavy precipitation events and river flows are observed and are projected to increase which intensifies damage risks from winter storms. A decrease in river and lake ice cover, as well as an incline of snow coverage, are anticipated. Nonetheless, some opportunities are expected to arise such as the increased potential for vegetation and forest growth, the rise in crop yields, the increase in the potential of hydropower as well as the increase and the stimulation of summer tourism (EEA, 2017). Studies conducted by the Finnish Meteorological Institute (2014) have shown that the rise of temperatures has been happening so rapidly in Finland particularly over the past 4 decades. This rise is nearly double than the global average “with the temperature rising by more than 0.2 degrees per decade” (Finnish Meteorological Institute, 2014).

According to the European Environment Agency (2017), the continental region marked in green (*figure 1*) is particularly susceptible to drier summers as well as the intensification and the increase in the frequency of heatwaves. This would upsurge energy demand for cooling and would also increase the risk of forest fires. Moreover, the region is at risk of a reduction in the economic worth of forests and is susceptible to increasing river floods (EEA, 2017). For example, on its online platform, the Climate Change Post (2018) presented that in the Czech Republic, severe heatwaves, comparable to record-breaking ones which have occurred in 1994 and 2006 are expected to occur once every 6 years on average in the mid-21st century.

Mountainous regions (*highlighted in purple in figure 1*) such as the Alps, the Pyrenees, and the Carpathian are according to the EEA classification (2017) susceptible to an increase of temperatures higher than European averages and a decrease in snow coverage. This change would have further consequences on ski tourism in these regions. It also has impacts on biodiversity as certain plant and animal species are likely to be affected (EEA, 2017).

2.1.2 Impacts of Climate Change on Medium-sized Cities in Europe

The European Environment Agency (EEA) Report No 12/2016 on urban adaptation to climate change in Europe (EEA, 2016a) highlighted that the cities are usually exposed to the same weather conditions as their surrounding region. Nonetheless, urban areas present a unique set of circumstances and are a couple of degrees warmer than their surrounding areas because of the waste heat from energy usages and the excess of built-up artificial surfaces rather than natural vegetation which affects the wind direction, the air temperatures, and precipitation patterns among others (EEA, 2016a). This was confirmed by the IPCC (2021) in its 6th assessment report which asserted that “increased urbanization can enhance warming in cities and their surroundings, especially during heat waves, and intensify extreme rainfall”.

Cities are often seen as areas of concentrated opportunities and wealth that have attracted people to settle in (Filho et al., 2019). According to the UN population program, in the middle of 2008, humanity reached the point at which, globally, the percentage of people living in urban areas exceeded the percentage of people living in rural areas. The percentage of people living in cities is expected to surpass 70% of the world's population by 2050 according to the World Population Data Sheet produced by the Population Reference Bureau (2016).

The relationship between cities and climate change is twofold. On one hand, the concentration of people and activities in cities has increased the pressure on the environment, accentuated air pollution and led to climate change, as cities account for around 80% of the world's anthropogenic GHG emissions (Filho et al., 2019). On the other hand, the growth of the urban population and the concentration of buildings and infrastructure systems in cities have amplified the exposure and vulnerability of urban areas to climate impacts (Hallegatte & Corfee-Morlot, 2010; Associate at the ICCCAD, interview, 2018; EEA, 2016a). Berdoulay & Soubeyran (2002) asserted that the contemporary wave of environmental concern has laid hold of urban planning through mixing considerations ranging from individual well-being to climate and natural threats impacting the planet. The Cities Climate Leadership Group underlined in its 'Powering Climate Action' report developed in collaboration with Arup (C40 Cities & Arup, 2015) that nearly all cities are threatened by global warming, and roughly 70% are at the present dealing with the impacts of this global issue. Cities could be particularly affected through storm surges, sea-level rise, inland and coastal flooding, landslides, and water scarcity (Filho et al., 2019).

Various scientists and researchers have presented the impacts of climate change on a wide range of city functions, services, and infrastructure affecting various sectors and disturbing the comfort of both people living inside and outside the city (Burch & Harris, 2014; Satterthwaite, et al., 2017; Filho et al., 2019). According to Adger et al. (2003) and Filho et al. (2019), climate change -leading to a changing pattern of extreme weathers- is likely to cause societal impacts through alterations in natural resources, ecosystems, water and food systems and as well as damage to the built infrastructure. For instance, inland and coastal floods could lead to the destruction of roads and buildings as well as the displacement of coastal residents. The low air quality and air pollution in cities could provoke respiratory diseases. Additionally, high temperatures and flooding could exacerbate the spread of viruses and waterborne diseases (e.g., Leptospirosis) (Filho et al., 2019). Not to mention, infectious illnesses could spread easily in urban areas where interaction with carriers could be more common (Santiago-Alarcon & MacGregor-Fors, 2020). Satterthwaite et al. (2017) asserted that cities are usually disconnected from sources of food supply which makes them more vulnerable to disruptions and disorders in the food system and impacts food security in urban settings. As a case in point, food shelves were empty for days following Hurricane Sandy in 2012 which impacted food supply underlining the vulnerability in urban food systems (Satterthwaite et al., 2017).

An expert on Climate change vulnerability and resilience in urban centers at the International Institute for Environment and Development (IIED) (interview, 2018) asserted that the effects of extreme weather events hitting cities are more likely to impact a larger number of people and cause more loss of life than sparsely inhabited rural areas. He elucidated that the high costs and the large investments made to develop the city infrastructure dramatically increases the financial losses following extreme meteorological events. He affirmed that "city services (e.g., the water

supply, the energy grid, and the sewage system) are intertwined which makes them vulnerable to big scale malfunctions when contrasted with decentralized systems in sparsely populated areas” (Expert on climate change vulnerability and resilience in urban centers at the IIED, 2018).

European cities, among other cities in the global north, seem to be more resilient and less vulnerable to the impacts of climate change (Chinowsky et al., 2011; Kraemer & Negrila, 2014; Associate at the ICCAD, interview, 2018). However, the situation is unlikely to remain so for long given that the impacts are expected to increase in intensity and in frequency (Burch & Harris, 2014). Heatwaves like the one that has devastated Europe in 2003 as well as other extreme weather conditions and heavy storms are expected to become recurrent and the consequences are expected to be substantially devastating if no proper adaptation measures are implemented (Robine et al., 2008).

‘Developed’ cities may also have to deal with long-term indirect impacts of climate change. More concretely, climate change is likely to increase the number of ‘environmental refugees’, or in other terms, individuals whose livelihood has been lost due to extreme weather events, drought, food shortages or other conflicts brought on by these impacts (Burch & Harris, 2014). According to Apap (2019) in a publication aiming at defining the concept of ‘climate refugee’, extreme climate events in developing countries are likely to result in mass migration flows into Europe to seek the opportunity to live safely in a territory that has not borne the brunt of climate change. Subsequently, member states are expected to be dealing with demographic changes and with the flow of environmental refugees (Apap, 2019). “...! Climate refugees’ may not only be individuals coming to the EU, but also EU citizens moving within Member States” affirmed Apap (2019). Research has shown that since 2008, on average, 26.4 million people have been forced to relocate every year due to floods, earthquakes, droughts, or windstorms (Apap, 2019). The number of ‘Environmental refugees’ is expected to increase in the light of climate change to reach more than 300 million climate refugees by the mid-21st century considering a 4 °C warming (Burch & Harris, 2014). Consequently, developed countries, including European states, should address tough questions regarding the ethics of denying environmental refugees seeking asylum, especially that these countries are the main contributors to GHG emissions.

Apap (2019)- in her report published by the European Parliamentary Research Service on ‘climate refugee’- asserted that by 2050, the urban built infrastructure is expected to at least double to be able to accommodate the urban population which is following an increasing trend due to urbanization and to environmental refugees. It has been presented, in a colloquium on ‘Metropolises and cities Intermediaries in Europe’ organized by the French National Federation of Urban Agencies (FNAU, 2018), that medium-sized cities would be particularly impacted given cities of this scale have the highest urban growth rate while densely populated big cities and metropolitan areas tend to stagnate. This rapid urban expansion in intermediary cities is critical as cities of this scale have a relatively weak capacity to inform policy and effectively manage these developments (Deutz, 2017). Not to mention, medium-sized cities seem to be particularly vulnerable to extreme meteorological events as they could have outdated infrastructure as well as limited human, technical and financial resources (Mungo, 2017). Certain mid-sized cities have developed adaptation initiatives to prevent losses associated with changing weather patterns in the light of rapid urbanization. However, accurate climate impact and vulnerability assessments and adaptation strategies and plans are still at an embryotic level (Burch & Harris, 2014).

Defining a mid-sized city is important as this thesis focuses particularly on cities of this scale. However, it is also hard to precisely define and quantify what a 'mid-sized city' is as this classification is particular to a certain context and could differ from one country to another. "What appears to be medium-sized at the European scale, may be considered large at the national scale or small on the global scale" (Giffinger et al., 2007). In a European context, cities ranging from a few tens of thousands to a few hundred thousand inhabitants can be considered mid-sized cities. The definition of a medium-sized city - as adopted in this research paper - will be further elaborated in section 3.2.1.

2.2 Adaptation of Cities in Europe to Climate Change

2.2.1 Challenges and Limitations

As an issue of global relevance, climate change has grasped the attention of different scales of governance as well as various stakeholders. Mitigation measures have been developed to reduce GHG emissions and assure climate neutrality. Nonetheless, researchers have shown that even if emissions were to stop in the present day, impacts of climate change will still be observed and felt for many years to come because of previous emissions (Frölicher, Winton, & Sarmiento, 2013). Hence, adapting to climate change is seen as an unavoidable complement to mitigation as asserted by the European council's conclusion on the EU climate adaptation strategy (Council of the European Union, 2013).

Adapting to unavoidable challenges has been at the core of human evolution, however considering climate challenges, it is inevitable to adapt to a changing environment in a sustainable manner (Westley et al., 2011; Pelling et al. 2015). Füssel (2007) asserted that adaptation does not exclusively mean protecting a region from probable impacts, but also entails building resilience, recovering, and profiting from any opportunity that could arise due to changes, shocks, or stresses. This was underlined by The European Environment Agency in its report No 3/2013 which affirmed that "adaptation is about managing change rather than simply protecting a certain state or restoring it" (EEA, 2013). In climate governance, adaptation refers to the development and the implementation of strategies, plans, and measures to respond to current and future impacts of climate change and reduce climate vulnerability (Adger et al., 2003; NASA, 2021). Adger et al. (2003) introduced 'vulnerability' as a "socially constructed phenomenon influenced by institutional and economic dynamics" and elucidated that the climate vulnerability of a system is influenced by its physical setting, its sensitivity, and exposure as well as its capacity to adapt to change.

Füssel (2007), Hallegatte & Coffee-Marlot (2010), Aylett (2015), and Campos et al. (2016) argued that since the beginning of the 21st century, adaptation has received far less attention than mitigation from local governments and European nationals. "Cities are including mitigation more frequently than adaptation across the different types of planning processes conducted by local governments" (Aylett, 2015).

The EEA affirmed in its report No 3/2013 that the development of adaptation measures and policies is still in its early stages especially that the dynamic participation of public authorities in the process is relatively recent. Fortunately, researches have shown that planning for adaptation

has rapidly proven itself in a policy area previously dominated by planning for mitigation (Aylett, 2015).

Adger et al. (2003) underlined the importance of considering socio-economic factors when addressing climate change and asserted that “understanding the present-day effects and response to climate variability at all levels of social organization is a prerequisite for studying the effects and responses to future climate change and for identifying the key determinants of successful adaptation in the future”. This was also addressed by the EEA in its report No 12/2016 which presented climate as a systemic challenge for cities given that it is intertwined with other environmental and socio-economic factors (EEA, 2016a). The report clarified that, on one hand, certain socio-economic configurations (i.e., urban sprawl and urbanization, economic development or decline, technological innovations, social exclusion, or segregations, etc.) are affecting climate change and its impacts. On the other hand, climate change leads to a vast range of social, economic, and environmental impacts in urban areas.

According to various researchers, adaptation should not be treated as a single isolated issue given that climate change affects various sectors, all scales, and levels of decision-making, and a wide range of actors with diverse backgrounds (Adger et al., 2003; Adger et al., 2005; Füssel, 2007; Mees et al., 2012). Mees et al. (2012) asserted that the ‘social complexity and the trans-disciplinarity of adaptation resulting in institutional ambiguity and fragmentation could lead to inaction as there is no clear delegation to who has is responsible and who has the power to act. Clar et al. (2012) also recognized the unclear or inadequate assignment of responsibilities as a challenge to climate adaptation, in addition to the lack of political commitment.

Adger et al. (2005), Füssel (2007), and Dessai et al. (2009) acknowledged uncertainty as a barrier to developing effective adaptation actions given that future evolution needs to be considered when tackling climate change (ADEME, 2018). This was confirmed by Berdoulay & Soubeyran (2014) who evoked that the uncertainty present in both human and nature systems as well as their interactions is a central concern that must be integrated at the heart of planning action. The European Commission (2013) affirmed in its EU Strategy on Adaptation to climate change that the lack of sufficient knowledge and uncertainty is an issue to be dealt with and underlined the necessity of improving the understanding and assessments and developing knowledge (European Commission, 2013). Not to mention, uncertainty makes the endeavor particularly challenging when it comes to engaging the public in issues of climate change especially that it is perceived by some in the distant future or far from their personal realm (Adger et al., 2003; Scannell & Gifford, 2011). Berdoulay & Soubeyran (2014) elucidated that the time horizons of climate adaptation often seem incompatible with human interest underlining that “we are often incapable to sacrifice immediate interest in the desired but uncertain future”.

Mees et al. (2012) presented ‘spatial diversity’ as a barrier to adaptation, especially that climate change affects populations, regions, and countries differently (Aaheim et al. 2010). Not to mention, local circumstances can amplify some impacts, as case in point, cities could be more vulnerable to heatwaves due to the urban heat island effect, thus the importance of developing “tailor-made” solutions specific to the needs of local communities (Saavreda & Budd, 2009). This was underlined by the EEA in its report No 3/2013 and No 12/2016 which asserted that there is no “one-size-fits-all” solution given the impacts of climate change can differ significantly between

territories across Europe. Adaptation responses are in fact shaped by environmental, economic, and social impacts and conditions (EEA, 2013). These responses could differ from one country to another due to: the nature of the experienced or projected impacts, the governance structure in place, the available material and financial resources, and the ability of a community to adapt and respond (EEA, 2013). Yet, the EEA (2013) report clarified that certain adaptation measures or initiatives could be employed in various parts of Europe given that certain areas have common characteristics and are dealing with similar consequences such as coastal cities and mountainous cities. The Council of the European Union's inferences on the EU climate adaptation strategy (Council of the European Union, 2013) stated that "most adaptation measures would need to be taken at national, regional and local level, as well as at cross-border level, and should be based on the best available knowledge and practices and the specific circumstances of the Member States".

An associate at the ICCCAD (interview, 2018) underlined that some other challenges could face European cities given that most of these cities have been built in the Middle Ages. He explained that adaptation options could be limited in such cities as the integration of adaptation measures is more complex in 'old' districts and cities that are already built-in comparison to newly developing cities and emerging expansions of urban agglomerations, especially if, at the same time, they are to preserve valuable heritage (Associate at the ICCCAD, interview, 2018).

It is also important to highlight that some adaptation actions do not increase resilience and are not sustainable. Others could appear to be efficient in the short run but prove to be against the long-term objective of the policy or could increase the climate vulnerability of other systems, social groups, or sectors (Schipper, 2009; Barnett & O'Neill, 2010). For instance, "installing air-conditioning units could seem to increase the resilience of built structures to climate events, yet if these units are not alimented by sustainable energy sources, they would increase the pressure on the environment" (Associate at the ICCAD, interview, 2018). These situations are examples of 'Maladaptation' which can be avoided by firstly taking into consideration social, economic, and ecological factors that increase vulnerabilities to climate change and secondly through assessing and evaluating the strategy (Magnan & Mainguy, 2014; Magnan et al., 2020).

2.2.2 Drivers and Opportunities

The EEA (2016a) asserted in its Report 12/2016 on urban adaptation to climate change in Europe that most Medium-sized cities are not yet adapting to climate change and improving their climate resilience. Nonetheless, some cities are demonstrating that mid-sized cities and small urban areas could take appropriate action to increase resilience (EEA, 2016a).

Adapting the city's physical and social infrastructure increases its resilience in the face of climate change (Rebotier et al., 2017). Sethi et al. (2021) argue that adaptation and resilience are two concepts of significant importance underlining the ability to respond to a changing climate, affirming that "a better appreciation of the relationship between the concepts of adaptation and resilience will provide more effective tools to plan for, and respond to, current and future change". According to Berdoulay & Soubeyran (2014), resilience is defined as the ability of a community to plan (prepare in anticipation), respond (during the emergency of the disaster), recover following the occurrence of a disaster, and draw lessons from experience to reduce vulnerability. Rebotier et al. (2017) see resilience as a series of social and physical efforts and a trajectory towards

developing adaptive capacity. Given that not every disruption could be forecasted or avoided, building resilience is crucial to prevent these disruptions from being disastrous.

According to the organization forum of 100 Resilient Cities, seven features make cities endure, react, and adapt to unanticipated stresses: reflective, resourceful, robust, redundant, flexible, inclusive, and integrated (100 Resilient Cities, n.d.). Consequently, resilient cities are the ones that understand and learn from experience and resort to unconventional and creative ways to endure and overcome predicted as well as unexpected stresses (100 Resilient Cities, n.d.). They are the ones that adopt a well-rounded management system, build capacity, and have the promptness to implement various strategies following the occurrence of unusual circumstances or in cases of emergency (100 Resilient Cities, n.d.). Resilient cities are also cities that adopt a comprehensive and cooperative governance approach and leadership and ensure taking appropriate actions (100 Resilient Cities, n.d.).

Zoeteman (2012) elaborated that the cities could have different drivers to set sustainable development strategies, adapt to changes in climate and increase urban resilience. These motivations could be legal obligations, environmental concerns, or financial and social motives (Zoeteman, 2012). For instance, in certain countries cities could find themselves obligated by the national governments to develop an adaptation plan. Certain key actors in city councils or local municipalities could be advocates of environmental and sustainable developments, therefore, are motivated to integrate environmental concerns, develop resilient cities, and adapt to climate change (Zoeteman, 2012). Some local governments take action because they're aware that adapting their cities reduces the cost of damages or the costs of taking action at a later stage. Other local governments could develop adaptation initiatives to brand themselves as sustainable and resilient cities to attract capital and investors and improve the quality of life of their inhabitants. These motivations are not mutually exclusive in a city, a combination of drivers is possible to move adaptation initiatives forward (Zoeteman, 2012).

Geneletti & Zardo (2016) asserted that "adaptation to climate change may be attained in different ways". To increase the adaptive capacity of a city it is however crucial to have sufficient resources, adopt market-based incentives as well as develop a long-term plan and sound policies and legal frameworks argued the EEA in its report No 3/2013 on adaptation in Europe. The latter builds on the ideas presented in the EEA report No 8/2009 emphasizing the importance of a political commitment is important as well as the involvement and the participation of stakeholders reinforced by a cooperative structure and a clear assignment of responsibilities (EEA, 2009). The EEA (2013) affirmed that some adaptation initiatives are already being developed and implemented across the continent. It also underlined that most of these actions do not come from policies exclusively devoted to addressing climate change as for instance adaptation actions are often embedded in strategies and policies which are designed and implemented for other purposes. For instance, developing green and blue urban infrastructure systems increases the esthetics of cities and make them more attractive, improves the local green economy, improves the health and wellbeing of city residents, and increases the adaptability of an urban area and its resilience to climate-related hazards (Kabisch et al., 2017).

An ecosystem-based approach to adaptation based on the management, preservation, and restoration of ecosystems that reduce the exposure of a territory to climate change was

introduced by the United Nations Framework Convention on Climate Change in 2008. Various researchers (Erwin, 2009; Jones et al., 2012; Geneletti & Zardo, 2016) investigated the potential of the ecosystem-based approach in urban areas offering “no regret interventions” and a series of co-benefits as opposed to a more traditional infrastructure-based approach. These co-benefits include the preservation of biodiversity, improved food security, enhanced tourism, and recreation opportunities as well as the possibility to control air pollution and mitigate climate change through increased carbon sequestration (Hallegatte & Coffee-Marlot, 2010; Naumann et al., 2011; Geneletti & Zardo, 2016). “As it relates to the long term, the financial or social cost of adaptation becomes acceptable insofar as the benefits that can be derived from it are associated with others that are more in the short term” (Berdoulay & Soubeyran, 2014).

Kabisch et al. (2017) underlined that the various types of adaptation measures increase the resilience of a city in the face of predicted and unpredicted environmental vulnerabilities. These measures are organized into three distinct categories: Grey, Green, and Soft.

Grey adaptation initiatives represent a traditional infrastructure-based approach founded on technical and engineering solutions such as dykes and mechanical barriers or defense systems. However, it has been argued that these solutions are at times considered not sustainable as “they often do not tackle the root causes of risk” (Kabisch et al., 2017). Additionally, they may increase the vulnerability of a city in the long run (De Vriend & Koningsveld, 2012; Kabisch et al., 2017).

Green adaptation measures exemplify nature-based solutions. This concept was introduced to emphasize the importance of creating flexible, integrated, and climate-proof solutions (Kabisch et al. 2017). For example, some urban ‘green interventions’, such as urban parks, green corridors, and bed reeds, can be intertwined with the built environment in deltas and coastal cities to reduce urban heat and flood risks while sustaining biodiversity (De Vriend & Van Koningsveld, 2012; EEA, 2013).

Soft measures consist of influencing human behavior using soft inducements or tools such as offering financial incentives or disincentives, awareness campaigns, or warning systems (EEA, 2013). For instance, certain financial incentives could be awarded stirring the development of green adaptation projects or “green businesses”. Kabisch et al. (2017) affirmed that soft, organizational as well as institutional, and economic measures are crucial for climate change adaptation and disaster risk reduction and suggested an intermediate “hybrid” approach combining these various types of measures to reduce hazards risks in an urban context.

Chhetri et al. (2019) proposed three stages of ‘nested adaptation’ -illustrating how one approach to adaptation could lead to another strengthening the robustness of a system in question. These three stages are: Coping, incremental and transformative adaptation. Coping strategies were outlined as short-term reactive measures that are often taken at a local scale to minimize the vulnerability of a system and reduce its exposure to climate risks (Chhetri et al., 2019). Coping actions serve to reduce the negative impacts following the occurrence of a disaster or a hazard. It is a passive reactive management approach considering current risk levels and current conditions (EEA, 2013). The inability of a system to cope with changes while maintaining its essential functions suggests the need for incremental adaptation (Klein et al., 2007; Chhetri et al., 2019).

Incremental adaptation consists of improving the resilience of a system in response to increasingly unfavorable conditions through the development of measures that are already in place or the introduction of new ones (Levin et al., 2012; Chhetri et al., 2019). An incremental adaptation is often effective in dealing with various short- and medium-term challenges (EEA, 2013; Magnan et

al. 2020). In some situations, the risks or damage could be so great, or the associated costs could be intolerable thus moving beyond coping and incremental adaptation is vital. In such cases, 'transformational' adaptation actions are indispensable, usually implying systemic or paradigm shifts (Kates et al., 2012; Lonsdale, Pringle & Turner, 2015). These measures consist of fundamental, often large-scale, changes in the social, economic, or biophysical aspect of a system such as the introduction of new crops or cropping methods, the relocation of people or a community to another area, or the change of the governance system in place (Kates et al., 2012; EEA, 2013; Lonsdale, Pringle & Turner, 2015; Chhetri et al., 2019).

Watts (2021) in a World Cities Summit webinar on Climate-Ready Cities & Sustainable Cities avowed that the climate adaptation present a great opportunity and that the cities are on the frontline of climate action, clarifying that decision taken now will dictate the future. This was also stressed by Downtown (2019) which affirmed that "the future is embedded in the now. Everything we do now is part of shaping it". Watt (2021) elucidated that the cities can respond immediately in the time of extreme climate events if they have thought about it in advance, underling the importance of planning and preparing for climate change through considering a systemic approach to resilience in cities.

According to Reeder & Ranger (2011) developing strategies and implementing them, is only one fragment of the adaptation process, another critical component to successful adaptation is the continuity of actions. Berdoulay & Soubeyran (2014) asserted that uncertainty encourages the adoption of a flexible approach to action that is constantly attentive to the fluidity of events, possible reversals, experiences and learning. Hence, the importance of developing a pathway or a 'possible route' identifying the evolution of adaptation measures in the light of evolving circumstances (Reeder & Ranger, 2011; Haasnoot et al., 2013). The 'Adaptation Pathway' concept considers a 'what if' scenario allowing for robust and flexible decision making in cases of uncertainty as it keeps future options wide and flexible (Haasnoot et al., 2013; Magnan et al., 2020). The EEA (2013) in its report on adaptation in Europe underlined the significance of this concept and emphasized the importance of monitoring and evaluation to develop new insights or experience and use it as a basis for decision-making. It also stressed the importance of developing a forward-thinking based on probabilities and risks rather than statistics from the past to deal with emerging hazards and risks and increase a city's adaptive capacity.

The concept of Adaptation Tipping Point (ATP) presented as a key to the adaptation pathway approach was first developed in the Netherlands. It defines the moment where alternative adaptation measures or strategies are needed (Kwadijk et al., 2010). Kwadijk et al. (2010) introduced the ATP as the point "where the magnitude of change due to climate change or sea-level rise is such that the current management strategy will no longer be able to meet the objectives". The EEA (2013) evoked this concept in its report No 3/2013 and defined two key questions for ATP to policymakers. The first determines the robustness of the strategy "How long will the strategy be efficient?" and the second allows to define how flexible the strategy is "How easy is it to change over time to an alternative strategy" (EEA, 2013).

2.3 Governance of Climate Adaptation

2.3.1 Defining Governance

Defining governance is essential to elaborate on the role of local authorities in mid-sized cities in governing climate change. The topic of governance has been studied and analyzed by various scientists and scholars. However, it is important to underline that the definition of governance could vary according to the discipline of the scientist; for instance, political scientists focus on the distribution of power horizontally and vertically, meanwhile, sociologists focus on the social and informal structure essential to the process of governance itself (Pohlmann, 2011). In environmental studies, climate governance is the response measures, the set of mechanisms, and the diplomacy “aimed at steering social systems towards preventing, mitigating or adapting to the risks posed by climate change” (Jagers & Stripple, 2003).

In their ‘Powering Climate Action’ report, C40 cities & Arup (2015) defined governance as “the collaboration between government, private and civil actors when setting a city’s strategic priorities, and when delivering and managing the city’s core services”. The United Nations defines governance as the implementation of economic, administrative, and political authority to manage a country’s affairs, comprising various sets of institutions, organizations, and methods that involve the state, the private sector, and civil society in a transparent way (Bressers & Rosenbaum, 2003). In a more general sense, governance is the act of achieving certain forms of public good and taking actions to ameliorate or prevent problems in society (Lulofs, n.d.). Based on the various definitions above, this thesis considers climate governance as the set of coordinated actions and mechanisms developed to reduce the stress on the environment and adapt the system in question to climate change.

Protecting citizens, developing the urban infrastructure, and providing a range of services is usually the responsibility of local, regional, or national governments which play a great role in the formulation of policies and the development of adaptation strategies. In addition, they have the institutional capacity to implement developed strategies (Lulofs, n.d.). The EEA underlines in its report No 12/2016 that a strong political commitment and leadership are essential to ensure that the government and public institutions are fulfilling their obligations in promoting the well-being of citizens and sustainably managing the available resources.

Although planning for adaptation seems to be the responsibility of governments (Mees & Driessen, 2011; Wilson & Termeer, 2011), various policymakers and scientists have endorsed the importance of the involvement of various stakeholders in adaptation (Füssel, 2007; Agrawala & Frankhauser, 2008).

Pohlmann (2011), Victor (2011), and (Hale, Held & Young, 2013) among other researchers argue that governance is no longer restrained to the narrow perception highlighting a direct hierarchical relation between ‘Governor’ and ‘Governed’. It has been recognized that a top-down, hierarchal approach is inept and does not correspond to the complexity of global problems such as climate change. For instance, laws designed on an international or national level could limit the capacities of local actors in taking appropriate measures or do not consider certain particularities of a context (Hale, Held & Young, 2013; Victor, 2011). As the topic of climate change is multidimensional, multi-

sectorial and of public concern, a new well-versed governance system is crucial to address the issue. A bottom-up approach, where local stakeholders play a significant role in the development of appropriate climate action, has proved to be more efficient. “A bottom-up perspective considers how local actors or events influence what is happening at ‘higher’ levels” (Pohlmann, 2011).

Researchers like Abbott et al. (2012), and Gordon & Johnson (2017) have elaborated on the concept of achieving governance through “orchestration” to limit the coercive authority and introduce ‘soft inducements’ to steer actors towards achieving certain goals. The concept of orchestration recognizes a horizontal relationship between various actors (Gordon & Johnson, 2017). This system of governance ensures the cooperation between city networks, international institutions, philanthropic organizations, and non-governmental organizations (NGO)s, businesses, and private corporations to plan for climate change. Pohlmann (2011) also argued that climate change governance should include different levels of governance (i.e., local, regional, national, supra-national, international, and global) as well as various stakeholders from different spheres of society.

2.3.2 Multi-level Governance of Climate Change Adaptation

Kohler-Koch & Rittberger (2006) have interpreted multi-level governance as “non-hierarchical forms of policymaking, involving public authorities as well as private actors, who operate at different territorial levels, and who realize their interdependence”. Kern & Bulkeley (2009) have defined this governance as competencies fluctuating between supranational, national, and local governments or institutions. Multi-level governance is also distributed across various territorial levels and among multiple actors in the public and private sphere (Kern & Bulkeley, 2009). According to the EEA report No 12/2016, the main pillars of multi-level governance are policy coherence, policy integration (through spatial planning and territorial governance), building capacity (through the different levels of governance), ensuring funding for adaptation initiatives, and sharing knowledge among different actors.

Different levels of governance play different roles in the development and implementation of adaptation measures. In 1992, the Rio Earth Summit established the climate regime under the leadership of the United Nations in a framework commending an era of international cooperation. The UN has thus raised the issue of climate change to a global political governance level (Aykut & Dahan, 2014). Since 1995, Conferences of Parties (COP) of the UNFCCC have been held yearly bringing together representatives of the signatory countries (195) and mobilizing a considerable number of actors and structures. These conferences supported the principle of shared responsibility and equality (Aykut & Dahan, 2014).

A factsheet developed by the European Commission on climate adaptation (2014) underlined that in 2010 the countries taking part in the UNFCCC approved that adaptation should be handled with the same level of urgency as mitigation. Moreover, the Sustainable Development Goals (SDG), set up by the United Nations General Assembly in 2015 and adopted by member states, highlighted the importance of working in partnership to reach a set of goals by 2030 (United Nations, 2015). These goals explicitly underlined the necessity of building resilient infrastructure (SDG 9) and the need for ‘Sustainable cities and communities’ (SDG 11) which are inclusive, safe, and resilient. They

also stressed the need for 'Climate Action' (SDG 13) to combat climate change and its impacts. The SDG13 included a clear reference to adaptation given that the goal 13.1 addresses increasing resilience and strengthening adaptability of climate-related hazards and natural disasters in all countries (United Nations, 2015). Adger et al. (2003) argued that the role of international action in adaptation is indispensable. Nevertheless, it is crucial to ensure synergies with more conventional analysis and policy development and focus on how policy can ensure the resilience of vulnerable communities and increase their adaptive capacity (Adger et al., 2003).

"To address first the issue of multi-level governance, the EU has developed into a system with multiple levels or spheres of governance, including European, national and subnational policy arenas" (Kern & Bulkeley, 2009). On its online platform, the European Commission (n.d.) presents the EU's long-term vision to cut down its emissions by 80 to 95% by 2050. To meet this ambition, member states have agreed on reducing 20% of their GHG emissions by 2020 and at least 40% by 2030 (compared to 1990 levels). They have also agreed on increasing the share of renewable energy consumption to 20% of the total consumption in 2020 and at least 27% in 2030. Not to mention, member states are keen on increasing energy efficiency by 20% on the horizon 2020 and at least 27% by 2030 (European Commission, n.d.). Furthermore, in 2013, the European Commission (EC) developed an EU adaptation strategy (European Commission, 2013) aiming to make different parts of the continent resilient to climate change through mainstreaming climate adaptation in different EU policies and using various instruments (e.g., standards at EU level or financial instruments) (Lukat et al., 2016). The EU adaptation strategy aims at contributing to a 'climate-resilient Europe and has a threefold objective. First, it supports adaptation at a national level. Second, it endorses decision-making at the level of member states. Third, it promotes the adaptation of vulnerable sectors (Lukat et al., 2016). In 2021 the European Commission presented a new EU Strategy on Adaptation to Climate Change (European Commission, 2021) underlining the necessity of building resilience especially when the COVID-19 pandemic showed that there is insufficient preparation to face various stresses and shocks. The newly developed strategy builds on the one developed in 2013 (European Commission, 2013) and expands to cover new priorities and areas based on acquired experience and increased ambition.

While mitigation targets seem to be more defined and accurate, adaptation targets are still relatively blurred and unclear. Nonetheless, to reach these targets, the EU is adopting a combination of regulations and financial support. The new EU strategy on climate adaptation (European Commission, 2021) is inciting the EU countries to increase collaboration on a European and international scale, push the frontiers of knowledge on adaptation, adopt a systemic adaptation response and speed up efforts. The European Commission offers its support in the design and implementation of national adaptation strategies through providing information and funding and developing initiatives like the 'Climate-ADAPT' platform to facilitate knowledge-sharing. European efforts have proved to play an important role and to be the main driver for the development of adaptation actions at the level of member states (Lukat et al., 2016). The European Commission not only focuses on the Member States but also on local authorities. Through the Mayors Adapt (the Covenant of Mayors for adaptation to climate change), it encourages cities and municipalities to include adaptation efforts as part of the climate policy.

The European Commission (n.d.) diffused on its official website that some trans-national policies have emerged in Europe insuring the adaptation of transnational regions such as the Pyrenees, the

Danube, the North Sea, and the Alps. It asserted that these policies are important to address issues such as cross-border coastal management or transboundary management of floods.

The European Environment Agency Report No 3/2013 underlined that at a country scale, national governments have developed policies and laws to meet EU's goals in reducing GHG emissions and adapting to climate change. National governments play the role of nexus between the concerns of the European Commission and the priorities addressed by regional and local governments (EEA, 2013). They are key to mainstreaming adaptation by offering the various stakeholders basic information on climate change scenarios and regional climate data, and providing an overall legal framework or a national adaptation strategy supporting sectoral or local initiatives (EEA, 2013).

Until 2013, before the development of the EU adaptation strategy, 17 EU countries had already produced National Adaptation Strategies (NAS) (Lukat et al., 2016). Following the development of the EU adaptation strategy, an increased number of member states developed a NAS (*figure 2*).

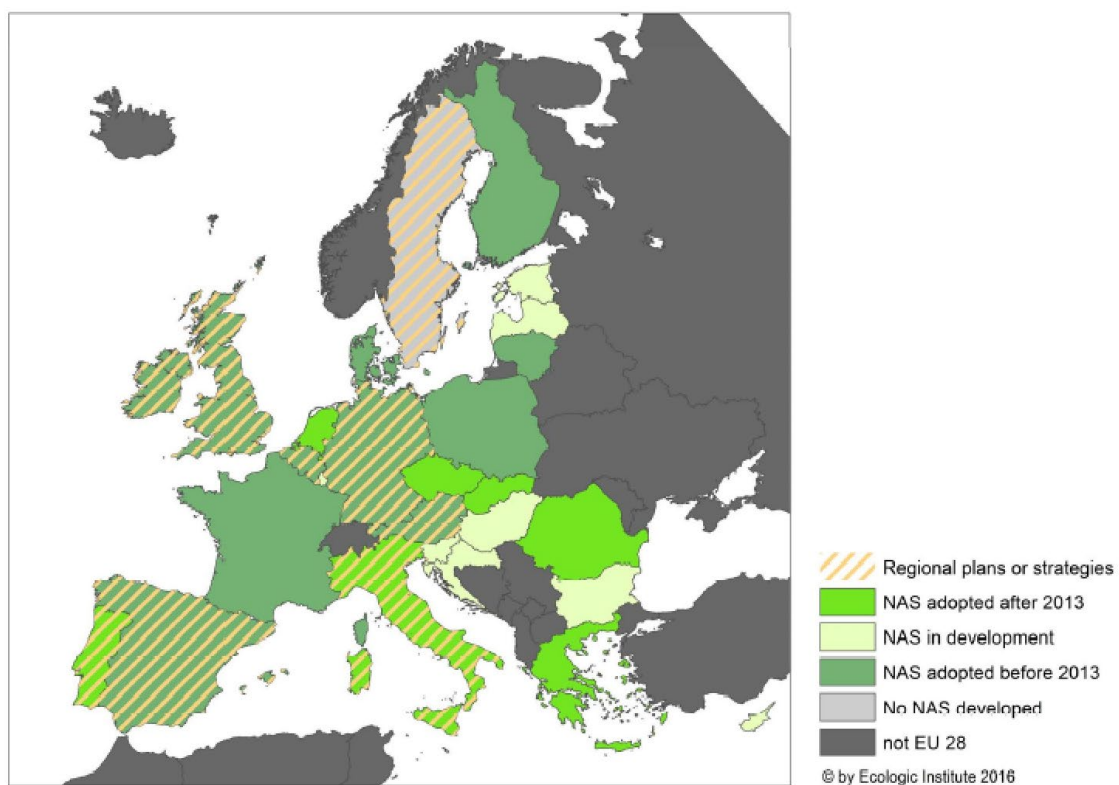


Figure 2 Development of National Adaptation Strategies (NAS) in the EU until and after 2013. Source: Lukat et al., 2016.

When the issue exceeds municipal boundaries, making it hard for local governments to take appropriate actions, regional governments play an important role in coordinating adaptation initiatives across municipal borders. A Network of Regional Governments for Sustainable Development (nrg4SD) was established in 2002 with the objectives of promoting the importance of addressing environmental and sustainability issues at this scale. It contributes to the development of territorial policies and encourages the exchange of knowledge and expertise at a regional level (Rei & Pinho, 2017). A RegionsAdapt initiative was launched at the Paris COP21 by the nrg4SD to incite cooperation for climate change adaptation at a regional level. It also allows for subnational governments to improve their capacity to effectively respond to climate change challenges (Rei & Pinho, 2017).

Finally, cities and local authorities are key players in the development and implementation of adaptation responses. The EEA report No 3/2013 on adaptation in Europe (EEA, 2013) stated that “local stakeholders know the specific conditions of their area very well and can therefore devise flexible solutions using their knowledge”. Initiatives such as “Mayors Adapt” have been developed to accentuate the role of local governments in developing comprehensive adaptation strategies

It is however important to underline that the role of local and regional authorities varies considerably from one country to another. The independence level of local governments depends on a city’s financial capacities and on its right to make autonomous decisions and actions (Kern & Bulkeley, 2009). The EEA in a report on urban adaptation (2016a) stated that “cities are strongly connected to their hinterland and within a region, and they depend on national governments and the EU to set the administrative and legal framework in which municipalities operate” (EEA, 2016a). Decentralized governments support the role of local governments, whereas this role is over-shadowed in countries with a centralized system (Tanner et al., 2009). In several European countries, increased decentralization has expanded local competencies and transferred authority from the national level to a subnational one (Kern & Bulkeley, 2009).

2.3.3 Role of Cities in the Global Climate Governance

Until the beginning of the 21st century, the role of cities in global climate governance was rather narrow and symbolic (Gordon & Johnson, 2017). Nonetheless, cities are progressively gaining an important role in the global response to climate change and the emergence of transnational systems for climate governance (Gordon & Johnson, 2017; Bulkeley & Castan Broto, 2013). The Paris agreement (UNFCCC, 2015) has enhanced the role of cities as it distinctly stated that it “welcomes the efforts of all non-Party stakeholders to address and respond to climate change, including those of civil society, the private sector, financial institutions, cities, and other subnational authorities”. Moreover, the Council of the European Union (2013) in its conclusion on the EU strategy on adaptation to climate change has stressed that the European Commission is supporting adaptation in cities through initiatives like the ‘Covenant of Mayors’. Gordon & Johnson (2017) presented cities as laboratories for environmental and climate experimentations.

In a colloquium on ‘Metropolises and cities Intermediaries in Europe’ organized by the French National Federation of Urban Agencies (FNAU, 2018) academics argued that medium-sized and intermediary cities still have a narrow role in the governance of climate change in comparison to metropolises given that the concentration of technical and financial resources as well as the focus of political agendas is on big cities. Mid-sized cities could however present some opportunities given that, in smaller administrations, integrating policy areas is easier as affirmed by the EEA in a report (2016a) on urban adaptation to climate change in Europe. The report stated that “small and medium-sized cities often claim to have few resources to build up effective governance structures, but they have the advantage that the lines of communication are short and straight and often the same staff or department is responsible for more than just one policy area.” (EEA, 2016a). The situation offers great potential and an opportunity for the integration of adaptive measures at cities of this scale.

According to Aylett (2015), local governments are slowly moving towards integrating environmental and climate change concerns into various municipal disciplines instead of isolating

the subject and working in silos. Environmental mainstreaming has been defined by the International Institute for Environment and Development (IIED, 2007) as “the informed inclusion of relevant environmental concerns into the decisions of institutions that drive national, local and sectoral development policy, rules, plans, investments and actions” (IIED, 2007). Mainstreaming adaptation efforts have proved to increase the efficiency and the effectiveness of adaptation responses as it aligns the efforts of different actors and decreases contradictions between various policies (Aylett, 2015). Avoiding trade-offs and creating synergies at a city level highly depends on the collaboration between various actors, organizations within and across cities (Aylett, 2015).

Gordon & Johnson (2017) have evoked that urban governance not only requires the engagement of various actors within a particular city but also entails coordinated activities and efforts between cities from different parts of the world. Partnerships and coalitions are allowing for cities to join forces and share best practices, such as C40, Urban Resilience Network, ICLEI, and Urban Sustainability Officers Network (McCarthy, 2017). Cities taking part in these urban coalitions are now integrating climate concerns into various disciplines such as urban planning and energy production (Aylett, 2014).

Bulkeley (2012) has raised questions about the nature of urban governance and has examined the various ways in which it could be accomplished. She further argued that governance could present itself in three different modalities. The first being a ‘Consent’ through using instruments for voluntary regulation such as setting standards (e.g., ISO). The second is a ‘Consensus’, for instance, belonging to certain associations guiding the development of ‘best practices’ (e.g., C40 cities). And the last being a ‘Concord’ or rather a strategic and a mundane form of governance to which one comply (Bulkeley, 2012).

In their ‘Power Climate Action’ report C40 Cities and Arup (2015) have labeled cities based on the level of participation of non-state actors in the decision-making process and the implementation of actions as follows:

- Commanding cities are the ones in which governance is rather hierarchal, the role of private actors is minimal, and regulations and enforcement are typically used to deliver action.
- Implementing cities are the cities that often operate without the input of private or other actors to deliver projects and programs. Providing cities are regarded as cities with a high level of control over the delivery of services and a great influence that enables them to take action.
- Legislating cities consider the role of different actors but still have a hierarchal view as governors set policies and legislation and other actions are required to act accordingly.
- Collaborating cities are cities in which the governance system is horizontal and city leaders work in partnership with various actors to leverage and influence their respective powers.
- Facilitating cities focus on creating an attractive environment allowing for the involvement of various actors as city leaders have limited power or resources to take direct actions (C40 Cities & Arup, 2015).

Studies have shown that cities, which are using governance approaches, such as ‘Commanding’ and ‘Implementing’, typically associated with stronger power and have a more autonomous model of governance cities, are not delivering the most actions in urban service fields like transportation, energy, and water management. However, cities with horizontal governance models such as ‘Facilitating’ and ‘Collaborating’ cities proved to be delivering a greater action in the same fields (C40 Cities & Arup, 2015). This proves that cities have a great potential to deliver action and not

only through the typical or conventional 'power' acquired by implementing a top-down approach (C40 Cities & Arup, 2015).

2.4 Adaptation Governance Support Tools

2.4.1 Role of City Networks

C40 Cities & Arup have underlined in their 'Powering Climate Action' report (2015) that cities have demonstrated to be taking remarkable action, even where they do not have 'strong power', through partnerships and links with other governments, cities, businesses, organization, and civil society (C40 Cities & Arup, 2015). City networking has proved to be important, especially that cities are becoming more and more connected globally (Acuto, 2013). Some networks have existed for decades, such as the Nation League of cities which was founded in 1924. Yet, city networks have been rising exponentially in the past few years as today there are more than 200 networks (Acuto, 2013, Acuto & Rayner, 2016). There's a wide range of kinds of networks and types of cities connecting with one another. Cities coming together often share a common vision to address a certain topic such as environment, poverty, energy, culture, peace, and gender (Acuto, 2013). Today, city networks and coalitions have become more focused and oriented towards environmental concerns (Acuto, 2013). These networks could be national, regional, or international. Throughout the time, more coalitions were predominantly national, however, since the beginning of the 21st century, they have become increasingly international in scale. Busch & Anderberg (2015) affirmed that various transnational networks emerged over the past decades to support the efforts of local authorities in addressing climate issues such as Climate Alliance and the Covenant of Mayors. These networks are not exclusive to metropolises and big cities, they're also permitting small municipalities and medium-sized cities to link across boundaries (Acuto, 2013, Acuto & Rayner, 2016).

Networks oriented towards environmental concerns allow for member cities to connect leaderships, share knowledge, practices, and experiences, issue joint policy initiatives, join activities and cooperate to address environmental and climate issues. They lobby for climate policies and exercise pressure on higher administrative levels including national governments and EU administrations (Emelianoff, 2013; Busch & Anderberg, 2015). These network permit member cities to connect efforts and develop inventive solutions to common problems confronted by local authorities (Kern & Bulkeley, 2009; Busch & Anderberg, 2015). C40 Cities & Arup have stated in the report on climate action (2015) that "cooperation raises ambition, and allows sharing of expertise and learning, collective development of new standards and approaches and the pooling of resources". City networks providing collaborative platforms supporting the adaptation of cities play an important role in the absence of clear national frameworks in support of local actions.

Since there is a vast range of city networks, this thesis focuses on coalitions that are particularly focused on the local governance of environmental and climate issues (e.g., climate alliance, eurocities, ICLEI, Urbact, etc.). City networks are examined to first allow for the selection of case studies and second to investigate climate actions taken by local governments in medium-sized European cities.

Climate Alliance: Founded in 1990, this network brings together members of municipalities, organizations, and NGOs from across Europe to address climate change adaptation and mitigation. This network allows its members to get advice on their local climate policies, be inspired and stimulated by the experience of other members and attend seminars and conferences allowing for the exchange of knowledge. It also allows local governments to stay up to date with news and publications on climate change and have their voices heard in important EU decisions on the topic. To join Climate Alliance, a city or a town council should commit to the network's objectives and apply for membership, the executive board will then decide whether the membership is approved or not.

Eurocities: Founded in 1986, its main objective is to reinforce the role of local governments in a multilevel governance structure, allowing city governments to take actions at a local level. Cities with less than 250,000 inhabitants can join as associate partners of the Eurocities network which brings together local governments of various European cities and offer them a platform for exchanging ideas and sharing knowledge. Eurocities works with European institutions and influences them to address common issues affecting the daily lives of European citizens. These issues are not particularly focused on climate change adaptation, however since climate change is having increased impacts on the citizens' day-to-day life, adaptation is being mainstreamed into various actions. A fixed fee is to be paid annually by governments that would like to join this network.

ICLEI: Founded in 1990, the International Council for Local Environmental Initiatives (ICLEI) works at various scales to build connections across different levels of governance from local to global to address complex environmental challenges. This network focuses on capacity building and knowledge exchange among cities to transform urban environments and supports urban sustainable developments. Joining ICLEI could benefit members as it helps connect and link like-minded leaders and cities which allows to nurture innovation and development in the field of environmental governance. This network also presents and showcases sustainability success which could inspire other cities, thus, accelerate climate action. ICLEI members pay an annual fee computed based on the number of citizens in the local government's area and on the average income of a country's inhabitants.

URBACT: Initiated in 2003, URBACT is a program that has been developed to promote and reinforce sustainable integrated urban development in various cities across Europe. The program's mission is to enable local authorities to work with one another and share knowledge. It also allows for the involvement of various stakeholders such as members of civil society and the private sector, practitioners, mayors, city managers, and other stakeholders from public agencies. This helps and speeds up the integration of the sustainable urban development process through identifying best practices and drawing lessons from one another to improve urban policies. URBACT is constituted of different networks including integrated urban development, environment, governance, economy, and inclusion.

2.4.2 Role of Adaptation Platforms

Palutikof et al. (2019) define adaptation platforms as 'enabling environments' that provide policymakers with guidance, tools, and necessary data to adapt to climate change. The content of these platforms could be delivered online or face-to-face via forums and workshops offering case studies on the planning and implementation of adaptation measures as well as peer-to-peer learning opportunities (Palutikof et al., 2019).

In its report No 5/2015, the EEA (2015) stated that these platforms allow decision-makers to access information promptly. Therefore, they increase the awareness of the need to adapt to climate change and address capacity and knowledge gaps. The report evoked that the role of climate platforms goes beyond providing information on climate impacts. These platforms offer a broader

set of services such as adaptation strategies, adaptation options, policy frameworks and processes, vulnerability risk assessments as well as various guidance tools (EEA, 2015).

According to the European Environment Agency (2015), web-based and online climate change adaptation platforms support the role of local authorities, Civil Society Organizations (CSOs) and city networks and present an important means to communicate experiences, evidence, and knowledge of the various stakeholders engaged in adaptation (EEA, 2015). Online webs facilitate coordination amongst various sectors and different institutional levels and are used as a basis for decision making and taking appropriate climate actions. Therefore, it is critical for online adaptation platforms, whether local, national, or European, to be constantly updated, user-friendly, and have appropriate content (EEA, 2015).

A transnational platform was launched in Europe in 2012 (Climate-ADAPT), hosted by the EEA, in response to the white paper published by the European Commission which highlighted the need to bridge the knowledge gap at an EU level. The online platform includes information and data collected and introduced by the Mayors Adapt initiative. It serves as a 'one-stop-shop' for information on adaptation in Europe. Its main purpose is to build a dependable, updated, and searchable database for decision-makers and stakeholders involved in developing adaptation policies and actions. The EEA (2015), in its report No 5/2015, affirmed that this online service allows access and share data on experienced and projected climate change in Europe. The Climate Adapt platform also gives information on the current and future susceptibility of various sectors and European regions to changes in climate. Moreover, it sheds the light on different national and transnational adaptation initiatives and presents several tools that support adaptation planning (EEA, 2015).

Other cross-border platforms have also been established such as the 'Pyrenees Observatory for Climate Change'. Not to mention, various European countries have developed a national adaptation platform. For instance, the United Kingdom established the UKCIP platform, and the Netherlands developed the Ruimtelijke Adaptie platform.

The 'Climate-Adapt' has been used as a filter for the selection of case studies in this research project. Medium-sized cities represent most signatories in Climate-Adapt indicating a higher need for support (Lukat et al., 2016). Cities with a 'Mayors Adapt' city profile on the Climate-Adapt platform have been investigated to understand the impact of the governing system on addressing climate change and developing respective strategies and policies.

2.4.3 Role of Civil Society

The European Environment Agency has stated in its report on urban adaptation to climate change (EEA, 2016a) that "peer networks and other new types of partnerships in governing urban adaptation can complement traditional governance mechanisms". In addition to city networks, civil society organizations have been leveraging climate actions at different levels of governance (Tosun & Schoenefeld, 2016). The conceptualization of civil society has changed over time. Today, it is seen as an independent sector consisting, predominantly, of a variety of voluntary associations and organizations with various interests, objectives, and ideologies (Cooper, 2018). Different typologies of civil society structures exist such as Civil Society Organization (CSO) (which

compromise NGOs and community-based organizations), social movements, labor organizations as well as online activities and social media communities (VanDyck, 2017). These structures have noticeably leveraged the participation of private actors in international politics (Tosun & Schoenefeld, 2016).

Over the past decades, citizens have been progressively involved in the process of global governance (Bernauer & Betzold, 2012). The World Economic Forum (2013), in its report on 'The Future Role of Civil Society', underlined that networks, communities, and organizations have allowed people to collectively address various societal and environmental challenges, including the issue of climate change. "A radical community-based approach to city-making has the potential to reconcile inclusiveness and stability with innovation, exploration, and change." (Downton, 2015).

Given that governments have been facing difficulties in adopting suitable policy responses, "civil society has become an important source of climate policy innovations and collective climate actions" (Tosun & Schoenefeld, 2016). The global governance of climate change has come to be less state-centric. Environmental movements and NGOs have been increasingly playing a crucial role in the development of new institutions and policies as well as their implementation (Bernauer & Betzold, 2012).

"Reflecting on global processes such as the G20, Rio+20 summit and ongoing climate negotiations, civil society leaders are looking for ways to deliver greater impact and better outcomes in global governance architecture." (World Economic Forum, 2013). The Rio summit affirmed that the involvement and the commitment of non-state actors are crucial to addressing environmental issues. Civil Society members have been recognized as 'partners' of the United Nations system, especially in environmental dialogues, due to their important role in implementation and service delivery. "A number of UN projects and programs are already benefiting from the contributions of NGOs in areas as varied as information collection and dissemination, policy implementation, monitoring and assessment, norm-setting, and policy development" (Esty, 2002).

The involvement of civil society in global environmental governance is achieved through offering technical expertise, expert analysis, and advice. "NGOs often have much better analytical and technical skills and capacity to respond more quickly than government officials" (Esty, 2002). Moreover, CSOs are capable of mobilizing public opinion through awareness campaigns and can help vocalize the opinions of people who are 'voiceless' or not well represented. Civil Society also plays a crucial role in supporting international agreements through evaluating negotiation efforts and monitoring the compliance of governments (Esty, 2002). CSOs succeeded in drawing connections between narratives of environmental sciences and social and economic impacts. They have proved to be able to show the intersection of climate change with issues such as social equality, economy, development, and health (Guy, 2018).

2.4.4 Role of Environmental Awards and Labels

Awards are given to recognize achievements in a variety of fields. It is a way to show that what has been achieved is appreciated and praised (Frey & Gallus, 2014). Awards can have different forms

such as medals, trophies, titles, or prizes, and play a particularly important role in voluntary achievements. It incentivizes and motivates people to work towards achieving the criteria set for the receipt of an award (Frey & Gallus, 2014). The award also sends signals or messages about the giver of the award himself. It helps the awarding bodies confirm their stand and support of a cause (Frey & Gallus, 2014). Similarly, dedicating awards to municipalities and local governments addressing issues of climate change through mitigation or adaptation measures permits to re-instate the commitment of the awarding organization to climate objectives, on one hand, and motivate cities to commit to climate action and to improve their performance, on the other (Frey & Gallus, 2014). The reviewed literature revealed that city branding -based on climate commitments and environmental policies- has in the recent years increased in popularity (Jonas, Gibbs & While 2011; Gustavsson & Elander, 2012; Joss, Cowly & Tomozeiu, 2013; Busch & Anderberg, 2015). Thereby, joining competitions as well as engaging in labeling processes -shedding the light on environmental initiatives taken at a local scale- allow to brand the city through portraying it as a frontrunner in environmental and climate actions.

Environmental awards and labels are tools that are also often used by local municipalities themselves to guide their climate actions (Baggioni & Bouisset, 2018). They are crucial especially that local governments often do not have sufficient knowledge to manage the transition and adapt their cities to changes in climate (Smart Cities Consulting GmbH, 2018). Local authorities aiming to receive 'green' labels, or an environmental award are steered by the requirements that are set to obtain these labels (Baggioni & Bouisset, 2018). As a case in point, a study conducted to assess the implementation of the Climate-Air-Energy-Territories Plan (PCAET) in France has shown that the 'Cit'Ergie'³ label served as a powerful tool and a framed method used as a reference to animate climate actions at a local scale (Baggioni & Bouisset, 2018).

Consequently, for this research, examining mid-sized cities that have received rewards for their environmental commitments could allow to develop an understanding of successful adaptation approaches. Various international and national awards were considered to filter out the selected case studies such as the European Green Leaf and the European Capital award presented by the European Commission.

The European Green Leaf & the European Green Capital Awards:

The European Green Leaf Award is open to all towns and cities across Europe with a population of 20,000 and up to 100,000 inhabitants, and the European Green Capital award is open to cities with over 100.000 inhabitants. Those initiatives are presented annually by the European Commission with threefold objectives. First, to identify and recognize the efforts of cities with remarkable environmental records. Second, to incite cities to be actively involved in addressing environmental issues and raising awareness. And third, to recognize cities which are leading the transition and encouraging other cities to move towards sustainable developments.

³ Cit'ergie, the French version of the European Energy Award label, is created to reward and support communities that are engaged in a quality management process, applied to the implementation of their PCAET (Métropole Rouen Normandie, 2017).

Each of the titles is awarded after cities participating in the competition have been benchmarked against one another to compare and assess the current situation and strategic approach adopted to achieve short and long term environmental and sustainable development objectives (European Commission, n.d.).

To join the competition, cities are asked to complete an application form and provide information describing the present situation, the implemented measures, future objectives, and proposed approaches and supporting their application with links to documentation where possible. The application is examined by a panel of expert who carries out a technical assessment. Shortlisted cities are then presented to jury members who select the winner (European Commission, n.d.).

The assessment criteria consider various areas including leadership and governance, local character and respect to cultural identity, attractiveness of the city and availability of amenities, commercial viability and success, environmental sustainability, healthy, community and wellbeing as well as access and connectivity.

CHAPTER 3: RESEARCH DESIGN AND METHODS

This chapter elaborates on the approach used for the collection, the selection, and the analysis of data to ensure attaining the objectives presented in the introduction, to answer the main research question, and eventually to identify the way forward in the governance of climate adaptation at the scale of mid-sized European cities.

The thesis is of a qualitative nature, given that the research unit (which is in this research medium-sized cities) presents a complex dynamic context. For this purpose, the research approach follows an in-context observational and interpretive pattern. A comparative case-study approach is adopted to juxtapose and compare the efforts of various local authorities in addressing the global issue of climate change at a local scale.

3.1 Research Framework

This thesis examines the studies, projections, vulnerability analysis, and efforts employed to improve the understanding of the impacts of climate change at the scale of medium-sized European cities. It investigates the approaches of local governments in addressing climate change by taking a closer look at the developed adaptation strategies, action plans as well as projects implemented to ensuring the adaptive capacity and increasing the resilience of the territory to climate events. It also examines the potentials and limitations of the governance of climate change adaptation in mid-sized European cities.

The research aims to underline favored governance approaches to adapt to climate change in medium-sized cities and increase their climate resilience. It adds to the existing literature by providing knowledge on climate governance, understanding the dynamics of adaptation governance in real world situations, and proposing an index allowing to evaluate the efforts of local authorities in mid-sized European cities to adapt the territory to climate change. This index provides researchers and policymakers with a tool allowing to assess the adopted adaptation governance approach. It also permits to determine the areas that require more focus as well as the progress of local governments in terms of climate adaptation.

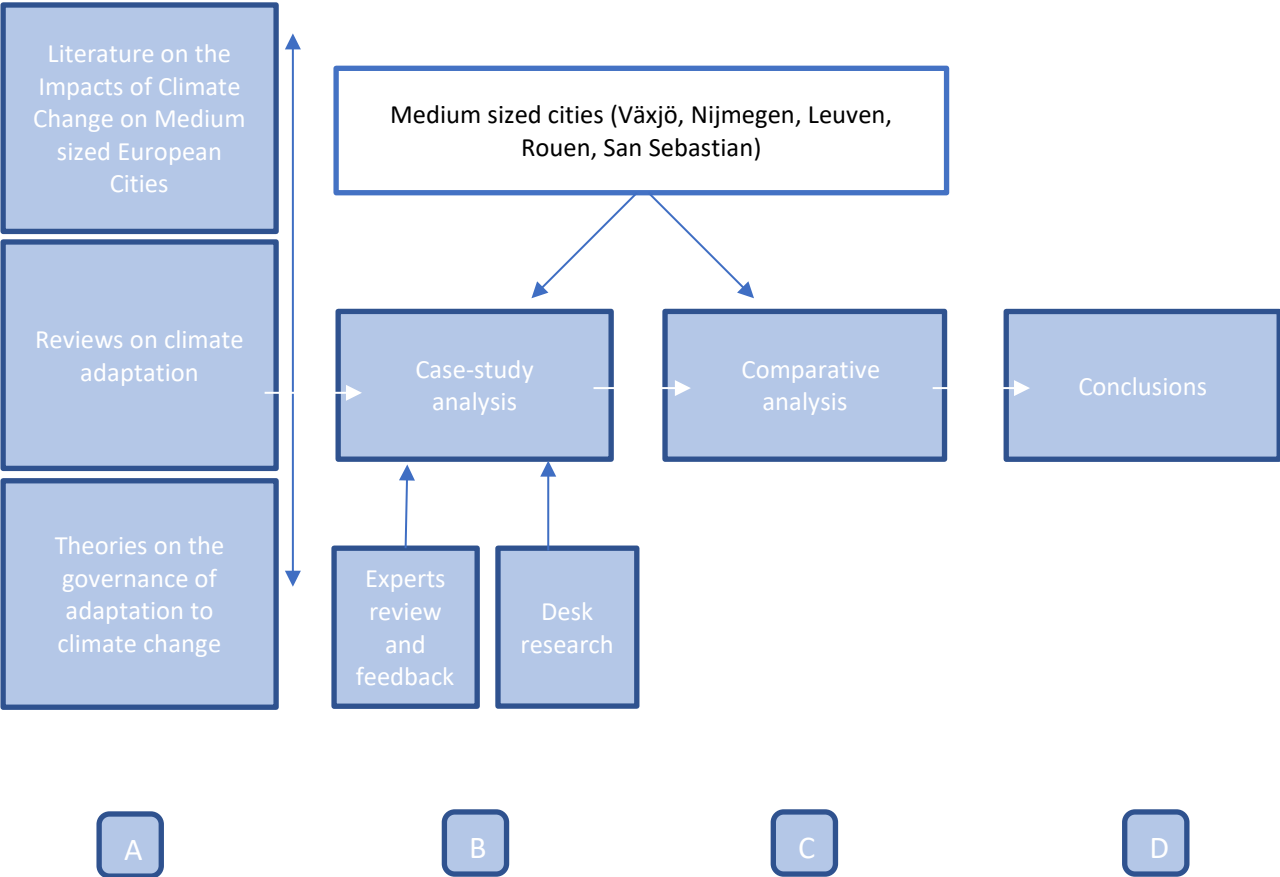
Throughout this research adaptation strategies in five medium-sized cities, selected as case studies, are contrasted with one another: Rouen (France), San Sebastian (Spain), Växjö (Sweden), Nijmegen (the Netherlands), and Leuven (Belgium). The selection of cases is further elaborated in Section 3.2

To get an improved understanding of the actual situation in each of the selected cities, the research resorts to primary data through conducting interviews (*refer to appendix I*) with various key actors in each of the selected cases, including regional and local authorities, decision- and policymakers, environmental experts, and researchers. The key stakeholders were interviewed to retrieve information that cannot be found in published literature and policy documents. For instance, questions were addressed to know if the municipality is planning on developing impact assessments to develop an improved understanding of impacts and if elected municipal representatives are aware of the importance of adapting the territory to climate impacts. Also, interrogations were raised to understand what the city's motivation is to address this global issue, the challenges faced at a local scale as well as the city's vision in the long term.

Additionally, a desk research approach is adopted building on secondary data from previous studies and literature reviews. As a new area of study and to develop a greater insight on each of the selected case studies, the scoping was not focused solely on scientific journal articles but also on press articles and environmental reports (developed by the World Bank, the World Economic Forum, C40 Cities, ICLEI, ADEME as well as other organizations and city networks). The thesis also investigates and reviews the environmental impact and vulnerability assessments produced at a local scale as well as political and institutional frameworks and adaptation strategies developed in each of the selected cases.

The case study approach allows deducing theories or a set of relations from a real-life contemporary phenomenon. However, it is important to note that the findings based on the selected cities and cases offer no grounds for generalizing the results. Yet, the selected medium-sized cities offer concrete examples of adaptation efforts emphasizing the importance of addressing the global issue of climate change on a local level. These examples help reveal the opportunities and barriers to adaptation actions at a local scale. Therefore, they allow reaching conclusions on the direction forward allowing local authorities to shape adaptive and climate resilient cities.

Figure 3 Research Framework.



As visualized in the figure above (figure 3), this research framework is carried as follows:

A: This step highlights the resources which have allowed the development of this research; particularly available scientific literature demonstrating the impacts of climate change on medium-sized European cities, reviews on climate change adaptation, as well as theories on the governance of adaptation to climate change.

B: This step explores the impacts of climate change, developed adaptation strategies and action plans as well as their implementation in 5 medium sized European cities selected as case studies: Växjö, Nijmegen, Leuven, Rouen, and San Sebastian. Interviews are conducted for primary data collection (*refer to appendix I*), and desk research is employed to develop on existing reports and literature reviews.

C: This step involves the comparison of the results obtained following the examination of the cities selected as cases. The confrontation of those results allows for the deduction of similarities, differences and relationships allowing for the development of conclusions

D: This step presents conclusions for developing a governance system supporting climate adaptation based on the results of the comparative analysis contrasting the selected medium-sized European cities.

3.2 Research Strategy

Since medium-sized cities are dynamic and complex and given that the issue of climate change adaptation is of modern-day concern, the thesis adopts a case study approach. This approach offers “a profound insight into the way various processes take place” (Verschuren & Doorewaard, 2010). Given that the sensitivity to impacts of climate change as well as adaptation strategies varies across European countries, the European Commission (2013) in its adaptation strategy underlines the need for a site-based analysis. The European Environment Agency in its report No 3/2013 stated that case studies are source intensive in the study of climate change, its impacts, and the design and implementation of adaptation strategies. They show potential and possible ways to adapt to climate changes but do not provide definitive solutions or answers as the most appropriate action depends on local and site-specific circumstances (EEA, 2013).

The examination of a case study permits to improve the knowledge and gain an in-depth comprehension of the climate vulnerability of the system in question as well as the challenges faced by the local authorities to adapt it to climate change. It also permits to determine the economic, social, and ecological significances of implementing action plans and projects increasing the resilience of the territory. Furthermore, it highlights the opportunities that could arise in addressing climate change at a local scale. This approach reveals the role and the power that local governments have in increasing the adaptive capacity of medium-size cities and making them resilient to climate change.

Five Medium-Sized European cities are selected as case studies to examine and better understand the capacity of local governments in cities of similar size in addressing a global issue such as climate change.

The comparison of these case studies allows for understanding the interactions between various players and stakeholders at different levels and for comprehending the specificity of impacts of climate change and the development of respective strategies in various regions across Europe. Therefore, in parallel to the case study approach, a comparative approach is adopted, contrasting the selected case studies to highlight differences and similarities in the local urban governance of climate adaptation. This qualitative method allows for the comprehension of a situation in a complex setting through examining cases of similar or different conditions and investigating real-life contemporary situations. The adopted methodology allows to examine approaches to the multi-governance of adaptation from international policy level to regional and local policy and implementation level. Additionally, it permits for the interpretation of results allowing for the development of conclusions, success factors, and recommendations. This thesis responds to the need for comparative studies highlighting key success factors for urban adaptation, given that various projects focus on a national level or select one case study at a local level (Coenen et al., 2012).

3.2.1 Research Unit

As this thesis tackles this global problem from an urban perspective, defining the research unit is essential for ensuring a focused study.

A city can be generally distinguished by its structured system of governance since it has been defined by the UN habitat as a highly organized community. Cities, in general, extend over a larger geographical area and have a high density of population and built infrastructure systems. Additionally, cities have rather dynamic economies as businesses and enterprises tend to set bases in them given the availability of labor and purchasing power. Every country has a wide range of criteria used as a basis to define a city. These criteria often include the density or the size of a population, the functionality of the city, a historic classification, and a political characteristic such as receiving national urban policy funds (Dijkstra & Poelman, 2012).

The categorization of mid-sized cities based on the number of citizens could differ from one source to another and that goes back to the fact that the definition of medium-sized cities is a factor of time and space. On a global scale, the population of mid-sized cities could range between 20,000 and 2,000,000 (Živanović, 2014). Meanwhile, in Europe, most literature reviews have defined Medium-sized cities as ones that host between 50,000 and 250,000 inhabitants. The number of inhabitants is the most used criteria to define Mid-sized cities in Europe, however, other criteria can also be used for this purpose, such as demographics, morphological aspects, the economy, and the functionality of a city or politics and laws. It has been presented, in a colloquium on 'Metropolises and cities Intermediaries in Europe' organized by the FNAU (2018), that demographics could demarcate medium-sized cities as these cities usually host a larger number of families, kids, and elderlies given that generally rents and services are more affordable in contrast to metropolises, which often attract singletons and active young professionals given that businesses and services are concentrated in big cities and rents are usually higher (FNAU, 2018).

The economic vitality and functionality of a city could also be used to categorize medium-sized cities. For instance, the economy of mid-sized cities is rather localized with specialized industries while big cities usually host big firms and multinational corporations (Hildreth, 2007). Lastly, in

some countries, certain laws or political constitutions are used to distinguish medium-sized cities from metropolises, giving more power to the latter (FNAU, 2018).

For data collection and to ensure focused research, this thesis adopts the number of inhabitants as a standard to define medium-sized cities given that this criterion is homogeneous in a European context. This research adopts the Covenant of Mayor's classification of medium-sized European cities with urban centers hosting between 50,000 and 250,000 inhabitants given that this platform is used as a basis for the selection of case studies.

To select the case studies, this research shows particular interest to mid-sized cities that have developed and implemented 'best practices' to increase the resilience of the territory to climate events. The focus on 'pilot' or 'model' cities allows understanding the motivation, drivers, levers, and opportunities that local governments of found in adapting to climate change. It also allows determining the challenges that are likely to be faced by medium-sized cities putting the efforts to adapt to climate change. This permits to draw conclusions and provide recommendations on the direction forward allowing local governments in cities of similar scale to adapt their territory and increase its resilience to climate events.

To define these 'pilot' cities, selection criteria filtered mid-sized cities that have developed climate and adaptation commitments, that are part of a city network allowing it to exchange knowledge and best practices with other cities, and that have received an environmental award or label.

3.2.2 Selection of Cases

For the selection of cases, this research starts with examining the local municipalities taking part in the 'Covenant of Mayors' initiative⁴ which was launched in Europe in 2008 with the determination of gathering local governments who voluntarily committed themselves to achieve the EU energy and climate targets.

The coalition brings together more than six thousand local governments with submitted action plans approaching climate change from a 'bottom-up' perspective. The covenant of mayors is seen as an interesting starting point as, like stated on the official webpage⁵, it is "the first and most ambitious EU initiative launched by the European Commission directly targeting local authorities and their citizens to take the lead in the fight against global climate change". At the time of the selection of the case studies (in 2018), 6038⁶ signatories were committed to the covenant of mayor's initiative. Given that the research is focused on medium-sized cities, these 6038 municipalities were narrowed down to 528 which fit this criterion (cities with a population between 50,000 and 250,000 inhabitants).

⁴ There are no fees for signatories to join the covenant of mayors, however, participants must prepare and submit a baseline-emission inventory, a risk and vulnerability assessment as well a 'sustainable energy and climate action plan'. They also must submit regular monitoring report evaluating the evolution of their action plan.

⁵ <https://www.covenantofmayors.eu>

⁶ An increasing number of signatories join the covenant of mayor's initiative each year, this is why it is important to underline that this number represents the number of signatories at the time of the selection of the case studies.

To further filter out the options, and as this research is focused on EU⁷ countries in particular, the municipalities which do not belong to member states of the EU were subtracted from the 528 municipalities. The reason for not taking these countries into consideration, even if they are geographically located in Europe, is because certain EU directives play a role in leading member nations towards addressing the issue and taking climate action as a part of the ‘multi-governance’ feature of climate change. Therefore, only 462 municipalities were considered for the selection of cases, all located in countries that are members in the European Union (in addition to the United Kingdom that was then a member of the EU). Among these 462 municipalities representing medium-sized cities in EU countries taking part in the ‘Covenant of Mayors’ initiative, only 74 were politically committed to taking action to adapt to climate change at the time of the selection of the case studies. Cities with a ‘Mayors Adapt’ city profile were of particular interest as it is important to assure the data availability for the cases that are being investigated to understand the impact of the governing system on addressing climate change and developing respective adaptation strategies and policies. To be able to select apposite case studies out of these 74 municipalities, the cities were cross-checked with the Climate-ADAPT platform which aims to support Europe in Adapting to climate change. The platform offers information about cities that have developed or implemented good practices and data about which implementation stage these cities are currently at. Out of the 74 signatories, only the 26 signatories with a ‘mayors adapt city profile’ at the climate Adapt platform were considered. “These city profiles of selected Covenant of Mayors and Mayors Adapt signatories showcase how different local authorities all over Europe are adapting to the consequences of climate change” (Climate-ADAPT Official Website, n.d.).

Among the 26 signatories with a ‘mayors adapt city profile’: 10 are preparing the ground for adapting their cities, 2 are assessing risks and vulnerabilities, 4 are identifying adaptation options, 4 are addressing adaptation options, 6 are in the implementation phase and no municipality is at the monitoring and evaluation phase. Results show that local authorities in EU member states are at various stages of preparing, developing, and implementing adaptation actions.

- **Preparing the ground:** Hasselt (BL), Burgas (BG), Rouen (FR), Worms (DE), Agioi Anargyroi-Kamatero (GR), Ilion (GR), Reggio Emilia (IT), Granollers (ES), Molina de Segura (ES), San Sebastian (ES).
- **Assessing Risk and Vulnerability:** Udine (IT), Granada (ES).
- **Identifying Adaptation Options:** Leuven (BL), Vicenza (IT), Barreiro (PT), Sant Cugat del Vallès (ES).
- **Assessing Adaptation Options:** Gent (BL), Aachen (DE), Treviso (IT), Torres Vedras (PT).
- **Implementation:** Næstved (DK), Roskilde (DK), Cascais (PT), Lleida (ES), Växjö (SE), Nijmegen (NL)

The climate-ADAPT initiative identifies signatories which are preparing the ground for adaptation as the ones working on setting up suitable coordination mechanisms, clarifying roles and responsibilities, identifying available data, and exploring funding opportunities. The cities which have assessed risks and vulnerabilities are the ones that have built an understanding of past, current, and future impacts of climate change, and have identified knowledge gaps. During the

⁷ The 27 member states of the European union considered for this research are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

'identification of adaptation option' stage, cities address identified concerns and explore their adaptation options. Furthermore, climate-ADAPT defines the assessment of adaptation options as the step in which various stakeholders collaborate to evaluate possible options in terms of benefits, efforts, and costs and prioritize actions. The implementation phase is in which cities develop an action plan and seek agreements among various stakeholders responsible to convert options into action. Finally, the monitoring and evaluation phase is the phase where cities understand their progress and performance to enable the improvement and the evolvement of adaptation over time (Climate-ADAPT Official Website, n.d.).

Cities that have taken part in social coalitions and networks are seen as interesting case studies given that literature reviews have highlighted the role and the importance of networking city leadership. Therefore, the adherence of these cities to coalitions or partnerships allowing local governments to share best practices and join forces was an additional criterion used for filtering out the case studies. This criterion narrowed down the 26 municipalities to 16 municipalities. This thesis focuses on coalitions that are focused on the local governance of climate issues, for this purpose, the considered networks include Climate Alliance, Eurocities, ICLEI, and URBACT.

Literature review also underlined the role of awards and labels as support tools in climate governance. Consequently, medium-sized cities which have received or were shortlisted to receive awards rewarding the best adaptation, transformation, or sustainable actions are seen as interesting cases. Examples of awards considered for this purpose are: 'the EEA Gold Municipality Award', the 'European Green Leaf Award', the 'Green Capital Award', the 'Transformative Actions Award' etc. This has narrowed down the 16 municipalities to 11. These 11 cities are: Gent (BL), Leuven (BL), Burgas (BG), Rouen (FR), Reggio Emilia (IT), Cascais (PT), Torres Vedras (PT), Granada (ES), San Sebastian-Donostia (ES), Växjö (SE) and Nijmegen (NL).

Given that Gent and Burgas are amongst the biggest and most populous cities of Belgium and Bulgaria respectively, and have a considerable economic and political weight, they are not considered as exemplar cases of 'medium-sized' cities. Thus, will not be considered for the selection of case studies. Moreover, due to various limitations, including the need to focus on a limited number of cities and the availability of documents in familiar languages, Reggio Emilia, Cascais, Granada, and Torres Vedras were not selected as case studies

Eventually, this research focuses on 5 case studies: Leuven, Rouen, San Sebastian-Donostia, Växjö and Nijmegen (*table 1 & figure 4*). It is however important to highlight that the selection of the cases was done at the start of the study in 2018. Thus, the cities that were reviewed could be at a different implementation stage by now. Also, more cities could have joined the climate Adapt initiative and committed themselves to adaptation, could have won environmental awards, or could have joined a city network or coalition allowing them to share knowledge and insights on the topic of environmental management and climate action.

Cities	Country	Population	Coalition	Award	Adaptation Stage (EEA, n.d.)
Leuven	Belgium	102,300 (Statbel, 2020)	Eurocities	The European Green Leaf Award 2018	Identifying Adaptation Options
Rouen	France	112 596 (INSEE, 2018)	Urbact (AIVP)	Grand Prix national du Paysage 2018	Preparing the Ground
San Sebastian	Spain	188.240 (INE, 2019)	Euro Cities (Associated partner)	Urbanism Award 2016	Preparing the Ground
Växjö	Sweden	91,000 (Tenje, 2018)	ICLEI	The European Green Leaf Award 2018	Implementation phase
Nijmegen	The Netherlands	170,739 (Municipality of Nijmegen, 2021)	ICLEI	European Green Capital Award 2018	Implementation phase

Table 1 Selected Case Studies.



Figure 4 Selected case studies.

3.3 Research Limitation

The selection of the case studies and the development of this research project are limited by various restraints.

Time and budget present a major constraint given that the research is only funded for a period of 3 years. The data collection process necessitated site visits and field studies to examine the situation on the ground; however, the budget dedicated for the development of this project is limited, therefore restricting the possibility of selecting a large number of cities. Not to mention, due to coronavirus⁸ travel restrictions imposed as of March 2020, visiting some of the selected cities has been unmanageable. Consequently, some field visits were canceled and most interviews with local actors had to be conducted online.

Additionally, the availability of primary and secondary data in familiar languages (English, French or Spanish) was an important criterion for the selection of case studies. Certain cities such as Cascais, Torres Vedras, Reggio Emilia and Burgas seemed to be interesting case studies, however, the availability of most secondary and/or primary data is in foreign languages, which complicates data collection.

Due to the above-mentioned limitations, the study was limited and focused on:

A. Impacts of climate change on European Cities in general; knowing that the impacts of climate change vary from one region to another within Europe and that cities have their ‘micro-climate’ and showcase a unique set of circumstances due to the excess of built-up artificial surfaces (i.e., urban heat island effect).

B. Medium-Cities, knowing that urban settings involve cities of all sizes or classes that could be differently affected by climate change and would have different capacities and resources for taking appropriate climate actions.

C. Adaptation approaches given that climate actions also involve mitigation measures. However, previous studies are focused on mitigation and there is a need for more research on climate change adaptation.

D. Case studies: 5 medium-sized cities are selected to help draw conclusions on the way the governance system should develop to adapt medium-sized cities to climate change.

It is important to mention that the cities selected as cases do not represent all medium-sized European cities, therefore the results cannot be generalized. Nonetheless, these results help achieve an understanding of the barriers and opportunities faced by local governments in adapting cities to climate change. They also help deduce the way forward in developing the governance system in medium-sized cities to adapt them to changes of climate and increase their resilience.

3.4 Conceptual Model

An initial scoping review aiming to map the literature on “climate governance” and “adaptation” was conducted to define focal areas, on one hand, and to develop a conceptual model of the governance of climate change adaptation on the other hand. Cities were targeted in the review

⁸ Coronavirus or COVID-19 is a contagious disease caused by a coronavirus discovered in 2019.

with a particular focus on local governance. As adaptation is a new area of study, and to develop greater insight, the scoping wasn't focused solely on European literature but included a global review of scientific journal articles as well as environmental reports.

This initial scoping review resulted in determining seven areas of focus in climate adaptation governance. These focus areas are presented next in sequential order, but the reality of the process is highly non-linear. "Systems do not always behave linearly and are not predictable based on their original state; they are adaptive" (Berdoulay & Soubeyran, 2014). Given that climate change adaptation and adaptive management are mutually beneficial areas of practice (Rijke et al., 2012; Marmorek et al., 2019) where actions are reassessed and developed based on new insights and experience regularly following an ongoing process, the order is presented cyclically in figure 5. Adaptive management is a governance approach that aims at addressing uncertainty "through continuous learning, involvement of multiple actors in decision-making processes and self-organization of the governance system" allowing to consider complex dynamics (Folke et al., 2005; Rijke et al., 2012).

- 1- Understanding the Impacts and Vulnerabilities
- 2- Developing Adaptation Strategies
- 3- Involving and Mobilizing Actors
- 4- Implementing Developed Strategies
- 5- Monitoring and Evaluation
- 6- Understanding Success and Limiting Factors
- 7- Improving the Governance System in Place

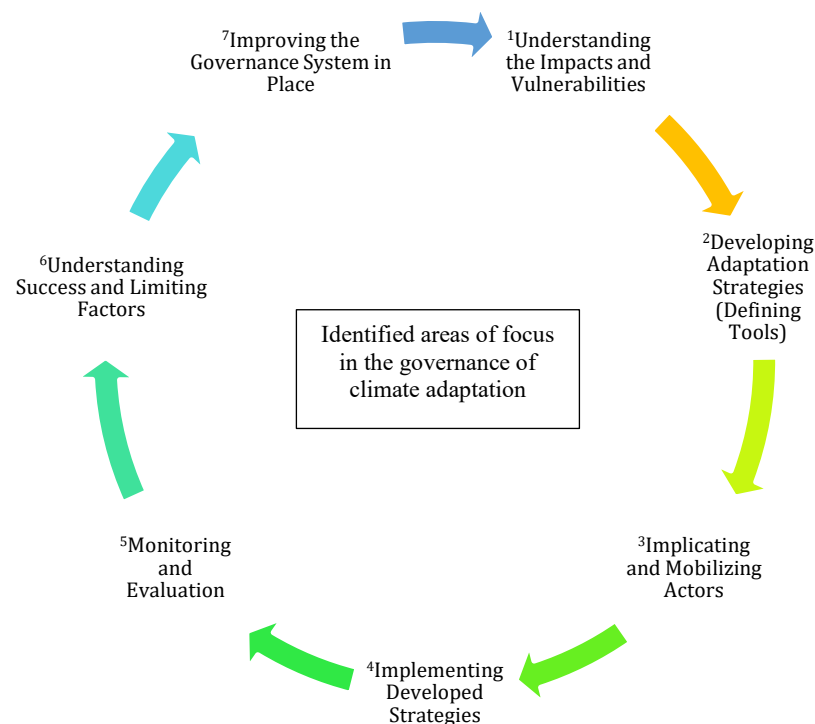


Figure 5 Developed Conceptual Model presenting the identified areas of focus in the governance of climate adaptation.

The identified areas of governance (highlighted in bold) are briefly defined below.

The World Bank in its guide to climate adaptation in cities (2011) as well as the EEA in its report on adaptation in Europe (2013) and its report on urban climate adaptation (2016a) underlined the importance of **¹understanding the exposure and the vulnerability of a territory to climate conditions and its impacts on various sectors** as a first step for the development of long-term resilience. “Identifying vulnerability is a necessary prerequisite to developing low-emission climate-resilient plans and strategies, and to ensuring that societies are resilient in the face of climate change” specified the UNDP (2010) In its guidebook ‘Mapping Climate Change Vulnerability and Impact Scenarios’. The UNDP (2010), the World Bank (2011) and the EEA (2013, 2016a) also stressed the significance of **²developing adaptation strategies**, in response to the identified exposures and impacts in consultation with various stakeholders.

The reviewed literature stated that it is important to **³mobilize key actors** (i.e., local municipalities, urban planners, decision-makers, organization, and civil society), identify their role in the development of politics, plans and comprehensive adaptation strategies, and implicate them in climate action (Pohlmann, 2011; Abbott et al., 2012; Gordon & Johnson, 2017 and Tosun & Schoenefeld, 2016). Edelenbos & Klijn (2005) asserted that “greater input from a variety of parties generates a variety of ideas and potentially enriches process substance”. Wamsler (2017) argued that the involvement of various stakeholders coupled with their mobilization to move towards attaining a common goal can increase the acceptability of suggested measures and strategies and help overcome barriers impeding their implementation.

⁴The implementation of strategy is the step that transforms strategies into actions. According to the ‘Powering Climate Action’ report developed produced by C40 Cities & Arup (2015), developing policy, regulations and partnerships is not sufficient. For instance, France, with its Grenelle II law (2010) and the law relating to the energy transition for green growth (2015), made it mandatory for local authorities to develop their territorial energy climate plans. However, ensuring the implementation of these developed plans is still a challenge for these communities (Baggioni & Bouisset, 2018; de Sartre *et al.*, 2021). It seems more efficient to deliver and implement climate action through a combination of traditional, city government-led initiatives (e.g., regulations or policy) together with other enabling activities or projects with private sector partners (C40 Cities & Arup, 2015).

The **⁵Monitoring and evaluation** of climate action are widely recognized as essential to help understand barriers to implementation of measures and to assess the efficiency of developed and applied climate solutions (Prutsch et al., 2015). Monitoring and evaluation systems allow informing stakeholders of any needs to improve the decision-making process and ensure more generally the development of adaptive strategies that are effective in the long-term (Harley & Van Minnen, 2009). Given that adaptation to climate change is a complex and ongoing process, the **⁶understanding of success and limiting factors to implementation** is essential to **⁷improve the governance system in place** (World Bank, 2011).

Using the elements of the conceptual model as a basis to compare the selected case studies allows forming an understanding of the similarities as well as the differences in governing climate change, adapting to climate change and building resilience in various urban contexts. This permits to comprehend key success factors in climate governance as well as the interactions between various players at different levels.

3.5 Data Collection Methods

The table below (*table 2*) presents the research methods followed to collect data including research questions, data required to answer the questions, the source of data as well as the method employed to access the necessary data.

Research Question	Data Required to Answer the Question	Source of Data	Method to access the Data
Are local authorities in mid-sized cities working on and supporting the development of an understanding of climate impacts and vulnerabilities at a local scale?	Review of impact, risk and vulnerability assessments developed by regional and local authorities to understand environmental, economic and social impacts in each of the selected case studies	Published literature: impact assessments, articles, adaptation platforms (national adaptation platforms, Climate Adapt), initiatives (Mayors Adapt) etc.	Desk research (printed documents and online research)
		Transcripts of interviews	Interviews with key stakeholders (residents, decision makers, experts)
Are local authorities in these mid-sized cities committed and engaging key actors to adapt their cities to climate change?	Review of adaptation policies, strategies and plans in each of the selected case studies as well as the mechanisms in place to mobilize actors.	Published literature: policies, urban plans, strategies, articles, adaptation platforms	Desk research (printed documents and online research) and review of projects
		Transcript of interviews	Interviews with key stakeholders (residents, decision makers, environmentalists...)
- What are the levers, drivers, barriers and challenges encountered by local governments to increase the resilience of medium sized European cities and adapt them to climate change?	Identified and unidentified opportunities and barriers to climate change adaptation in the selected cities.	Published literature: Communications of local governments; articles; adaptation platforms	Desk research (printed documents and online research)
		Transcript of interviews	Interviews with key stakeholders (residents, decision makers, environmentalists and experts; NGOs)
Is the adopted adaptation governance approach increasing the adaptive capacity and resilience of cities to climate event (need to develop a tool to assess adaptation governance efforts).	Develop a tool to assess the efforts of local authorities in collaboration with key actors to ensure the adaptability of the each of the selected case studies to climate change	Published literature: articles, policies, strategies, adaptation platforms	Development of criteria to evaluate climate adaptation adaptation governance in mid-sized cities
		Transcript of Interviews	Interviews with key stakeholders (residents, decision makers, environmentalists...)

Table 2 Data collection methods.

3.6 Data Analysis: Urban Climate Adaptation Governance Index

Various indexes have been proposed by various researchers, private and public organizations in support of climate governance. For instance, a City Resilience Index (CRI) was developed by Arup⁹, presenting a self-assessment tool carried out by local governments to help them understand and measure the resilience of their cities. Other tools, standards or indicators have also been developed to quantify certain dynamics in urban contexts like the ISO 37120 standard, issued by the 'International Organization for Standardization' as an 'indicator for city services and quality of life' to assess the resilience of cities (UN Habitat, 2017). However, these tools are rather general, not focused particularly on the topic of climate change and adaptation. This would give a less accurate assessment of climate adaptation efforts, as for instance, a city could be resilient to earthquake or political instabilities but not prepared to deal with heatwaves or other climate change related issues or vice versa.

Furthermore, a climate change vulnerability index was released by Maplecroft¹⁰ allowing administrations to determine their susceptibility to climate-related natural adversities and sea level rise. The proposed tool also permits to assess the future vulnerability through considering the adaptive capacity of a government to combat climate change. The tool responds to the limitation addressed by Miola, et al. (2015) underlining the need for relevant indicators focusing on future hazards as opposed to current climate risks. Yet this tool does not determine or assess adaptation governance efforts in increasing adaptive capacity and ensuring urban resilience.

The European Commission (2013) in its adaptation strategy underlined that there is no commonly adopted assessment tool allowing to assess the effectiveness of various adaptation initiatives, making it is hard to define whether the governance of climate change and climate actions in place are effective and ensure more resilient cities.

Tanner et al. (2009) developed an index assessing the capacity of 10 South and Southeast Asians to explore the ability and willingness of governments to plan and implement an integrated climate change resilience program based on a governance framework considering 'good urban governance attributes' in Asia. These attributes include "(1) decentralization and autonomy, (2) accountability and transparency, (3) responsiveness and flexibility, (4) participation and inclusion and (5) experience and support." (Tanner et al., 2009). Nevertheless, the developed index is of qualitative nature and does not cover the governance efforts that follow the development and implementation of policies increasing the resilience of the territory to climate events. Not to mention, it is focused on Asia and is only based on five indicators, which "not all are covered in each case and therefore represent independent variables, thereby limiting the extent of comparative analysis" (Tanner et al., 2009).

The thesis intends therefore to fill the stated gaps and build on existing indexes through focusing on climate adaptation governance. Consequently, it proposes a tool to make the concept of 'urban climate adaptation governance' perceptible and palpable through allowing to quantify a characteristic which remains to date unquantifiable and rather of qualitative nature. The proposed

⁹ A multinational firm providing consulting services.

¹⁰ A global risks advisory firm.

tool does not solely consider the development and implementation of adaptation strategies; but also embraces a “feedback phase” which includes the understanding success and limiting factors, as well as factors related to improving the governance system in place.

This segment explains the methodology adopted to evaluate the efforts of local authorities in increasing the adaptive capacities of the urban environment to climate events in the mid-sized cities selected as case studies.

3.6.1 Assessment Questions

For each of the 7 areas of focus identified and presented in the conceptual model (*figure 5*), a scoping review with a particular focus on European literature (of scientific journals, publications and reports developed by various international organizations on adaptation governance) was performed to determine assessment indicators of governance factors that can increase the adaptability of a mid-sized city and its resilience to climate change. Only literature and factors relevant to Europe and mid-sized cities were retained for the review.

Indicators identified through the literature review were then used as a basis for the development of an urban climate adaptation governance index allowing to assess governance efforts to increase the adaptive capacity of a mid-sized city through the development and implementation of climate adaptation policies. The index takes the form of a checklist consisting of a series of close-ended questions presenting desired situations or best practices based on existing knowledge. These questions are addressed to check whether indicators of governance factors increasing the adaptability of a mid-sized city and its resilience to climate change are in place or not.

Assessment indicators, defined in each of the identified areas of focus in the Governance of the Adaptation to Climate Change based on existing literature, are presented below.

Understanding Impacts and Vulnerabilities – Assessment Indicators

As a topic of multi-level governance, the competencies of addressing climate change fluctuate between supranational, national, regional, and local governments (Kern & Bulkeley, 2009). This stresses the need for “bottom-up, local- and regional-scale economic assessments to inform cross-scale decision-making and to provide important empirical evidence to improve global evaluations of impacts and vulnerability” (Hallegatte & Corfee-Morlot, 2010). The World Bank in its guide to climate change adaptation (2011) and an associate at the ICCCAD (interview, 2018) confirmed that the steppingstone to climate adaptation is to understand the vulnerabilities of a territory to climate change. In its guidebook ‘Mapping Climate Change Vulnerability and Impact Scenarios’ the UNDP (2010) stated that, to ensure the resilience of territories, it is important to understand their vulnerability from a sub-national perspective. Thus, the importance of developing regional and local climate vulnerability assessments that include an identification of environmental risks as well as vulnerable sectors and population (World Bank, 2011). Upon the determination of the vulnerability, the UNDP (2010) advises mapping the information to determine the likely locations of the vulnerable population and sectors of possible climate risks.

In some regions and cities, there is no document particularly dedicated for this assessment but there are studies or publications highlighting the environmental impacts of climate change as well as its socio-economic ramifications. Communication strategies and awareness are crucial to

increase awareness and bridge the gap between climate change and personal concerns (Scannell & Gifford, 2011), especially given how climate change remains abstract or impersonal to many people. Uncertainty and the perception that impacts are to be felt in the distant future or far from their personal realm compounds these challenges (Scannell & Gifford, 2011).

Corresponding indicators are aimed at verifying whether cities have developed regional and local vulnerability assessments, identified the sensitivity of their territory, the impacts on sectors, and socio-economic repercussions. Questions are also raised to verify whether the developed knowledge is communicated with the public.

The questions below are developed to be able to assess the ability of medium-sized cities in developing an understanding of vulnerabilities and impacts to climate change to govern climate adaptation.

- 1- Is there a regional vulnerability assessment of the impacts of climate change?
- 2- Is there a local impact assessment particular to medium sized cities (50,000-250,000)?
- 3- Is there an identification of environmental consequences of climate change?
- 4- Is there an identification of socio-economic repercussions?
- 5- Have the sectors impacted by climate change been identified?
- 6- Is there an identification/mapping of vulnerable areas?
- 7- Is the public informed of the impacts of climate change on the city? (e.g., availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)

Developing Adaptation Strategies – Assessment Indicators

The European Environment Agency highlighted in its report on urban adaptation in Europe (EEA, 2016a) that the complexity of climate change requires the involvement of various levels of governance. It also underlined in its report No 3/2013 that the national governments play a crucial role in linking climate concerns addressed by the EU and the priorities of regional and local governments. Adaptation strategies are not only needed at a national and regional scale but also at a local scale. The World Bank in its guide to climate change adaptation (2011) underlined that adaptation strategies need to be formulated based on a thorough comprehension of impacts. It also emphasized that the adaptation of cities “must be location-specific and tailored to local circumstances” as they present dynamic systems and face climate impacts. The UNDP (2010) stated that “adaptation to climate change is very site-dependent, and local planning decisions will be critical to tailor almost every single adaptation action to the conditions in which it will take place”. The European Environment Agency on its online platform stressed the importance of the prioritization of policies, actions, and projects, based on the level of urgency and the availability of resources, is necessary before their implementation. Planning for climate change does not simply entail developing ad-hoc and stand-alone adaptation measures but requires “making climate change and adaptation an integral part of their systematic medium- and long-term planning and budgeting processes.” (Labate, 2018).

The following questions are addressed to evaluate whether the selected medium-sized cities have developed well-versed adaptation strategies to address climate impacts and risks.

- 8- Is there a national action plan requiring local or regional authority to take climate actions?
- 9- Is there a developed regional adaptation strategy?
- 10- Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)
- 11- Is there a developed local adaptation strategy?
- 12- Is the developed local strategy “tailored” in response to assessed impacts and vulnerabilities?
- 13- Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?
- 14- Does the adaptation strategy include medium term plans (Horizon 2030)?
- 15- Does the adaptation strategy include long term plans (Horizon 2050)?

Implicating and Mobilizing Actors – Assessment Indicators

The adaptation process is a fundamentally participatory process, relying on all actors, public or private, from different sectors and governance levels (Berdoulay & Soubeyran, 2014; Ross et al. 2015). Science input is key to support community processes (Ross et al., 2015). Territorial- and urban planners play an important role as well given that an integrated spatial planning approach is necessary for climate adaptation, and land use planning is evolving as one of the policy areas that have direct impacts on climate adaptation (Yiannakou & Salata, 2017). The World Bank (2011) has underlined in its guide to climate adaptation that civil society involvement is particularly needed to ensure the protection of vulnerable populations. Moreover, as stated by Lukat et al. (2016), “bottom-up initiatives designed directly by local actors may have greater potential to directly address and/or integrate climate adaptation than traditional spending priorities designed at a national level by sectoral authorities”. The Climate Action Network (2013) stressed in a report the role of the private sector and businesses in addressing climate issues and increasing resilience, especially that “the private sector represents close to 75% of global climate finance flows”. Researchers argue that mainstreaming climate adaptation strategies and including it within existing policy framework and processes across various sectors is more resource-efficient than developing separate processes to support adaptation (Lebel, Li, Krittasudthacheewa, et al., 2012). The involvement of various actors is not sufficient, the definition of roles and the coordination of inputs and synergy in planning is fundamental for effective participation of these actors (Lukat et al., 2016). Developing a shared vision amongst actors from various sectors and levels based on a multi-disciplinary discussion coupled with their willingness to engage is crucial for climate adaptation (Ross et al., 2015). International networks, partnerships, and coalitions (such as C40, Urban Resilience Network, ICLEI, and Urban Sustainability Officers Network) are enabling cities to join forces, share best practices and integrate climate concerns into various disciplines, (McCarthy, 2017; Aylett, 2014). These dimensions are reflected in the indicator list shown below.

The questions below are raised to evaluate whether climate strategies and actions are being coordinated among various actors.

- 16- Are environmentalists and scientific experts involved in the development of the adaptation strategy?
- 17- Are urbanists and city planners involved in the development and implementation of the adaptation strategy?

- 18- Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?
- 19- Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?
- 20- Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?
- 21- Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?
- 22- Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)
- 23- Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e., ICLEI; Eurocities etc.)?

Implementing Developed Strategies – Assessment Indicators

In an interview, an Associate at the ICCCAD (2018) stated that implementation of the developed climate plan and adaptation strategies is the point where intentions, visions, and policies are turned into reality. He elaborated that this step is important to test the efficiency of the developed strategies. The World Bank (2011) in its guide to adaptation stressed that the availability of technical, financial, and human resources is necessary to ensure the implementation of environmental and adaptation initiatives and projects. The World Economic Forum (2013) in its report on the 'Future Role of Civil Society' underlined that CSO plays a crucial role in pushing the efforts of local authorities to adapt to climate change as it allows society to voice concern and articulate demands. Not to mention, environmental labels and awards are often used by local municipalities themselves to guide their climate action as they recognize achievements in this field and motivate governments to work towards achieving the criteria set for the receipt of an award (Baggioni & Bouisset, 2018). The European Environment Agency in its report No 3/2013 presented that the implementation of a combination of adaptation approaches, known as grey, green, and soft, improves the adaptive capacity of cities. Grey adaptation approaches consist of bigscale engineered projects designed and implemented to protect a city from the impacts of climate change (e.g., flood barriers and dikes). Green adaptation approaches are the ones that emphasize the role of nature and green infrastructure in increasing the resilience of a territory in the face of climate extremes (EEA, 2013). Soft adaptation approaches include the development of warning systems, awareness campaigns, financial incentives, or disincentives (i.e., taxes or subsidies) (EEA, 2013). According to the Third Generational Environmentalist (E3G) Research Team (2011) "improving transparency and accountability is essential to empower citizens and civil society to ensure that tackling climate change is seen as central to the national interest.". Accountability and transparency are thus important to ensure the development of effective responses and enhance the potential for delivery.

The review of the above-mentioned sources resulted in the development of indicators assessing whether a local government succeeded in translating intentions, visions and policies into reality through the implementation of adaptation measures as shown in the list below.

- 24- Are short-terms adaptation measures and initiatives being implemented?
- 25- Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?
- 26- Are financial resources made available for the implementation of adaptation strategies?
- 27- Are human resources made available for the implementation of adaptation strategies (a multidisciplinary team that possesses the skills, experience, and know-how necessary to carry out the implementation of adaptation measures)?
- 28- Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?
- 29- Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)
- 30- Has a city received an award or a label for implementing an award worthy environmental initiative?
- 31- Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?
- 32- Are green adaptation approaches implemented?
- 33- Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives, or disincentives (i.e., taxes or subsidies)?
- 34- Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?

Monitoring and Evaluation – Assessment Indicators

Monitoring and evaluation is an essential periodic process to inform decision-making and to improve the developed strategies (Coast Adapt, 2018). It is also fundamental for providing accountability and ensure better practices (Prutsch et al., 2015).

As adaptation to climate change is a relatively new issue for cities and local authorities, the monitoring and evaluation of the implemented strategy are important to assess progress, ensure transparency, enhance commitments, and hold governments accountable (ADEME, 2013; E3G Research Team, 2011). According to the French Environment and Energy Management Agency (2013) a combination of various qualitative and quantitative indicators is required to measure the effectiveness of an adaptation policy. The overall responsibility for monitoring and evaluating adaptation approaches usually lies with government agencies or ministries managing adaptation policies (Prutsch et al., 2015). In many cases, data is not collected by a single organization. Therefore, the monitoring and evaluation process must be based on various local, subnational, and national sources (Coast Adapt, 2018).

The questions below are raised to assess whether mid-sized cities are monitoring and evaluating the implementation of adaptation strategies.

- 35- Is there a monitoring and evaluation of adaptation at a local or regional level?
- 36- Is the existing monitoring and evaluation continuous and periodic?

- 37- Are there personnel or a committee dedicated for monitoring and assessment at a local level?
- 38- Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?
- 39- Are there quantitative indicators to measure the implementation of adaptation policies at a local level?
- 40- Are there qualitative indicators to measure the implementation of adaptation policies at a local level?

Understanding success and limiting factors – Assessment Indicators

Barriers and constraints to adaptation strategies and their effectiveness in increasing resilience can be identified through monitoring and evaluation processes. According to Lukat et al. (2016) filling knowledge gaps and identifying opportunities and challenges in adapting to climate change results in better-informed decision making. Reporting and communicating the results of monitoring and evaluation also allows for targeted groups to understand those barriers and improve and develop better adaptation policies and practices (Prutsch et al., 2015). The German Society for International Cooperation, in a publication on monitoring and evaluation of a National Adaptation Plan (GIZ, 2017) stated that “making results publicly available also allows for better exchange of experiences and awareness-raising and promotes planning at local levels as well as mobilization of resources”.

The questions below are raised to assess whether a local government have understood limiting and success factors and if it is aiming at identifying knowledge gaps.

- 41- Are M&E reported and communicated with targeted groups to inform practice and policy?
- 42- Are opportunities and levers to the implementation of adaptation identified?
- 43- Are the barriers obstructing the implementation of adaptation policies and practices identified?
- 44- Is the local government supporting projects studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?

Improving governance system in place – Assessment Indicators

Climate Adapt communicated on its online platform that “it is crucial to access and correctly interpret information about the projected climate impacts” to develop a long-term adaptation strategy and increase the resilience of a territory to climate change. According to various researchers (Reeder & Ranger, 2011; Haasnoot et al., 2013; Magnan et al., 2020) implemented policies should be regularly updated to integrate new information provided through monitoring and evaluation especially that adaptation is a learning process. This was also underlined by the EEA in its report No 3/2013 which presented the ‘Adaptation Pathway’ concept considering a ‘what if’ scenario is important for robust and flexible decision making in cases of uncertainty. It describes the ability to act based on new insights or experiences, therefore it is crucial for taking decisions under deep uncertainty (EEA, 2013). In its report on urban climate adaptation, the EEA (2016a) stated that coping actions and preparing to react to expected and unexpected events are

important. It is adopted in cases of emergency through the implementation of a disaster risk plan, such as rebuilding houses after the occurrence of a hazard (EEA, 2016a).

45- Are vulnerability assessments updated periodically to integrate new findings and insights?

46- Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?

47- Are existing adaptation policies periodically updated?

48- Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?

49- Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)

50- Are emergency plans developed to overcome risks or unexpected extreme environmental events?

To answer the addressed questions and to evaluate the efforts of local governments in improving the adaptive capacity of mid-sized cities and increasing their climate resilience, this thesis reviews both primary and secondary data for each of the selected case study.

3.6.2 Quantification of Assessment Results

The close-ended questions addressed in the previous section (section 3.6.1) present desired situations, according to existing literature, in different stages of adaptation governance allowing to improve the adaptive capacity of a city and increase its resilience to climate change. Following this logic, each question answered with a 'Yes', represents a positive or an "ideal" situation and accounts for 1 point. On the other hand, each question answered with a 'No' represents the lack of application of adaptation governance approaches improving the adaptive capacity of a city and accounts for zero points. Answers representing situations in which adaptation approaches increasing the resilience of an urban context are not fully developed are indicated by a '±' and account for 0.5 points. As there is a total of 50 questions, the sum of the points (p) is divided by 5 to have a numerical value (α) over 10. This score represents the 'urban climate adaptation governance Index'. In other terms, it offers a quantitative measure to assess adaptation governance approaches and actions increasing the capacity of a city to endure and overcome impacts of climate change. Restricting the scoring system in this index to 3 possible answers (yes, no and ±) permits to simplify the assessment, especially as this thesis does not aim on providing an absolute value for adaptation governance efforts as much as it aims to provide an easy-to-use tool allowing to benchmark adaptation governance efforts in various mid-sized cities to deduce favored approaches increasing the city's adaptive capacity and resilience to climate change.

$$\alpha = \frac{\sum_1^{50} p}{5}$$

It is important to indicate that the value (α) could vary overtime and only represents the urban adaptation to climate change index at the time when the thesis is developed.

Below, the numerical values of urban climate adaptation governance obtained are further explained to develop a further understanding in each of the selected cases:

- **0** represents a minimum and indicates a null level of consideration to climate change adaptation.
- **$0 < \alpha \leq 2$: Non-existent to Weak Urban Climate Adaptation Governance:** Meaning the governance system in place is not well developed to adapt cities to climate change. These cities could be fragile and exposed due to a lack or poor understanding of impacts of climate change on a particular context given that a thorough comprehension is a steppingstone to adapt cities (World Bank, 2011; Associate at ICCCAD, interview, 2018).
- **$2 < \alpha \leq 4$: Weak to Moderate Urban Climate Adaptation Governance:** Which could identify a fragile adaptation approach based on a weak understanding of impacts or a weak political dedication to develop corresponding strategies given that a political commitment is crucial to develop adequate adaptation policies (Clar et al, 2012).
- **$4 < \alpha \leq 6$: Moderate Urban Climate Adaptation Governance:** Meaning local authorities have understood the importance of building the adaptive capacity of a given mid-sized city to increase resilience in the face of climate impacts, and is developing adaptation policies, but could lack the appropriate tools or resources to implement adaptation strategies (World Bank, 2011).
- **$6 < \alpha \leq 8$: Moderate to Favorable Urban Climate Adaptation Governance:** Which could mean that local authorities have comprehended the necessity of making climate commitments to address the impacts of climate change on their cities. This could mean local actors are experimenting with various adaptation policies to increase the resilience. However further research, resources or investment could be needed to understand the impacts on the city and develop adequate adaptation initiatives to increase the resilience. Well-rounded adaptation strategies and policies need to boost learning capacity, be flexible to integrate new insights and involve various actors (Suárez, et al., 2016).
- **$8 < \alpha \leq 10$: Favorable Urban Climate Adaptation Governance:** In this case, local governments are leading adaptation to climate change and setting an example to other mid-sized cities through adopting “best practices” based on an exhaustive understanding of impacts. These authorities have the tools and the resources to implement developed adaptation policies and are addressing barriers to implementation. Nonetheless, even mid-sized cities with a governance approach embracing adaption approach to increase urban resilience could still be vulnerable to severe impacts given that adaptation is a learning process and various challenges need to be addressed (Suárez, et al., 2016).

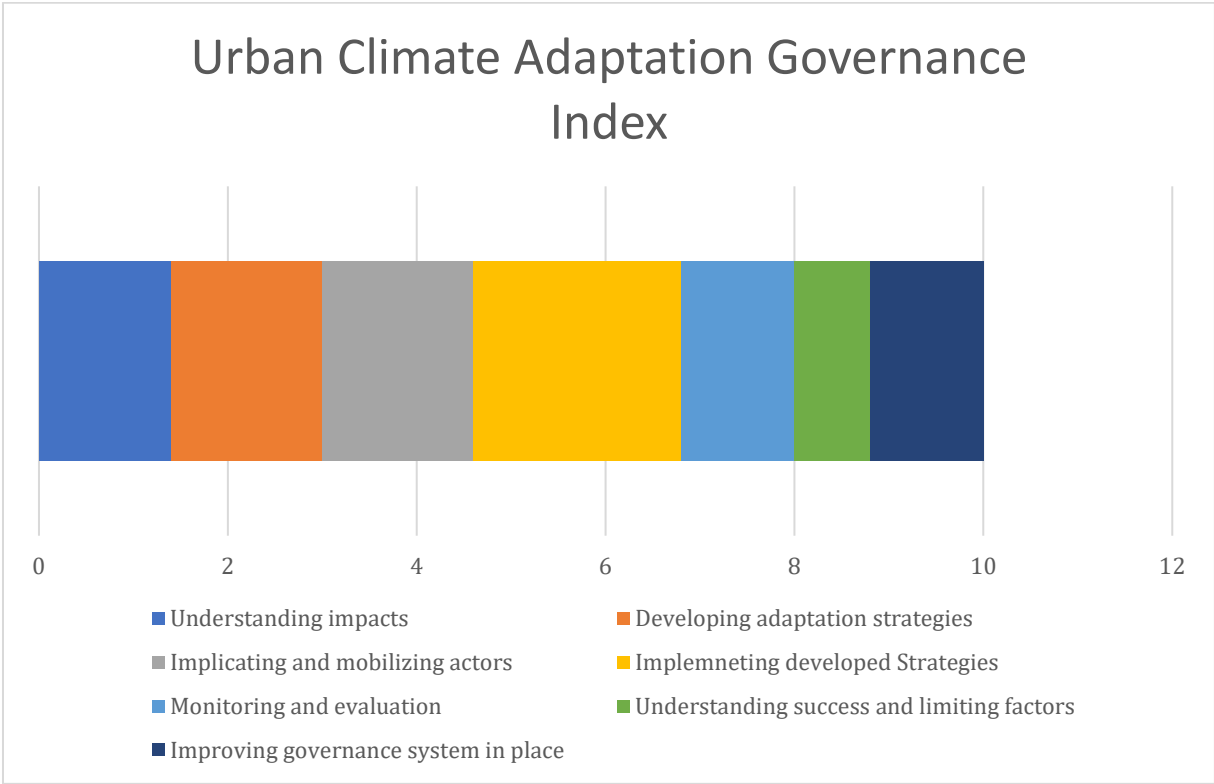


Figure 6 Graphical representation of the quantification of various areas of governance according to the developed urban climate adaptation governance index consisting of 50 assessment questions.

The diagram above (figure 6) shows a graphic representation of the urban climate adaptation governance index based on the suggested quantification approach. This underlines that, according to the literature reviewed to develop the index based on 50 assessment questions, not all the defined areas of adaptation governance have equal “weight”. Some areas seem to be more prominent than others. The implementation of developed adaptation strategies seems to be the most crucial aspect of increasing the adaptive capacity of a city to boost its urban resilience. The areas of understanding impacts, developing adaptation strategies as well as implicating and mobilizing actors seem to have equal “weight”, while other areas of governance seem to have a different influence on the index score. This however does not undermine the value of other areas of governance of climate adaptation or makes for instance the area of ‘understanding success and limiting factors’ of less importance given that adapting to climate change requires an integrated governance approach entailing the self-organization of the governance system, the involvement of various stakeholders in the decision-making process, and continuous learning (Folke et al., 2005; Rijke et al., 2012). Not to mention, the areas of monitoring and evaluation, understanding success and limiting factors and improving governance system in the place all feed into the feedback phase that follows the implementation of developed strategies, and the “weight” of all these areas combined makes this phase particularly prominent which underlines the importance of adaptive management and the continuous improvement of adaptation approaches (Rijke et al., 2012; Marmorek et al., 2019).

3.6.3 Application of the Conceived Index

The developed index, including the 50 assessment questions presented in section 3.6.1, is to be tested in this research project. The tool is used to assess the climate adaptation governance of the selected mid-sized cities (Rouen, Nijmegen, Leuven, Växjö and San Sebastian). Data allowing to answer the developed close-ended questions is collected -through conducting interviews and the review of grey literature (i.e., adaptation Strategies & Action Plans, Guides, Reports, Factsheets, Audiovisual media, e-prints etc.)- and presented in Chapter 4 for each of the selected case studies. The governance index is then computed to present a value over 10 evaluating adaptation governance efforts -increasing the adaptive capacity and urban climate resilience- in each of the selected cases. Once the methodology is tested, a feedback loop will define the areas that need to be addressed to further develop this index and make sure it can be applied to other medium-sized European cities.

CHAPTER 4: RESULTS

The French environment and energy management agency (ADEME, 2018) its guide on addressing the issue of climate change underlined that to adapt regions and cities, changes in our way of life are necessary and new policies and adaptation practices are needed. Many countries, cities, and territories are already committed to adapt to climate change, while others haven't developed their adaptation strategies or actions.

This chapter applies the developed methodology to investigate the governance of climate change adaptation in medium-sized European cities and its role in affecting urban resilience. Leuven, Nijmegen, Rouen, San Sebastian, and Växjö are examined and presented according to the different areas of climate adaptation governance defined in the developed conceptual model.

Consequently, research is conducted to examine the understanding of impacts and vulnerabilities, the developed strategies, and the implication and mobilization of various actors in the development and the implementation of the developed policies in each of the selected mid-sized cities. It will also inspect the actual implementation of adaptation approaches, the availability of monitoring and evaluation systems allowing to comprehend the success and limiting factors in increasing a mid-sized city's adaptive capacity as well as efforts to improving the governance system in place. Lastly, adaptation governance efforts are assessed using the index developed in section 3.6. In the following chapter, the results of the selected cases are compared with one another to allow for understanding the barrier, levers, and opportunities to climate change adaptation at the scale of mid-sized European cities.

4.1 The case of Rouen, France



Rouen, selected as one of the case studies, is examined to develop a better understanding of the governance of climate change at the scale of a mid-sized city in France, a European country with a centralized governance system (Samuel, 2017). This city permitted to test the developed

methodology as it was the first city to be analyzed using the research approach presented in Chapter 3.

To assure data collection, first, published literature and documents were reviewed including articles developed by the regional environmental agency of Normandy, articles published in the local press and on the city's official website, environmental and climate policies and strategies as well as urban plans developed by the Metropole Rouen Normandy and the municipality of Rouen. Second, a field visit to the city of Rouen was assured to develop an improved understanding of the urban layout of the city, including the presence of green areas and water elements that could play an important role in soothing the climate. Following the field visit, interviews were conducted with various actors including a representative of the Metropolitan area of Rouen at the directorate of environment and energy, as well as two municipal employees working in assuring the development and implementation of sustainable development and climate strategies which will be referred to in this research as Municipality of Rouen employee in charge of ecological transition and Municipality of Rouen employee at the directorate of attractiveness and living environment. Interviews were also conducted with a climate researcher at the University of Rouen as well as activists and workers at the environmental agency. A Skype interview was also assured with the Cit'ergie consultant of both the city and the metropolitan area of Rouen prior to the field visit. These interviews allowed to have access to information that is not shared in documented and published literature and to understand the point of view of local actors, who have a better understanding of local geographical, political, and environmental circumstances. Mostly the local actors who were interviewed for this case preferred to remain anonymous and to contribute to this scientific work with no mention to their names.

The data collection is synthesized and organized following the 7 areas of focus in the governance of climate adaptation which are identified and presented in the developed conceptual model (Section 3.4).

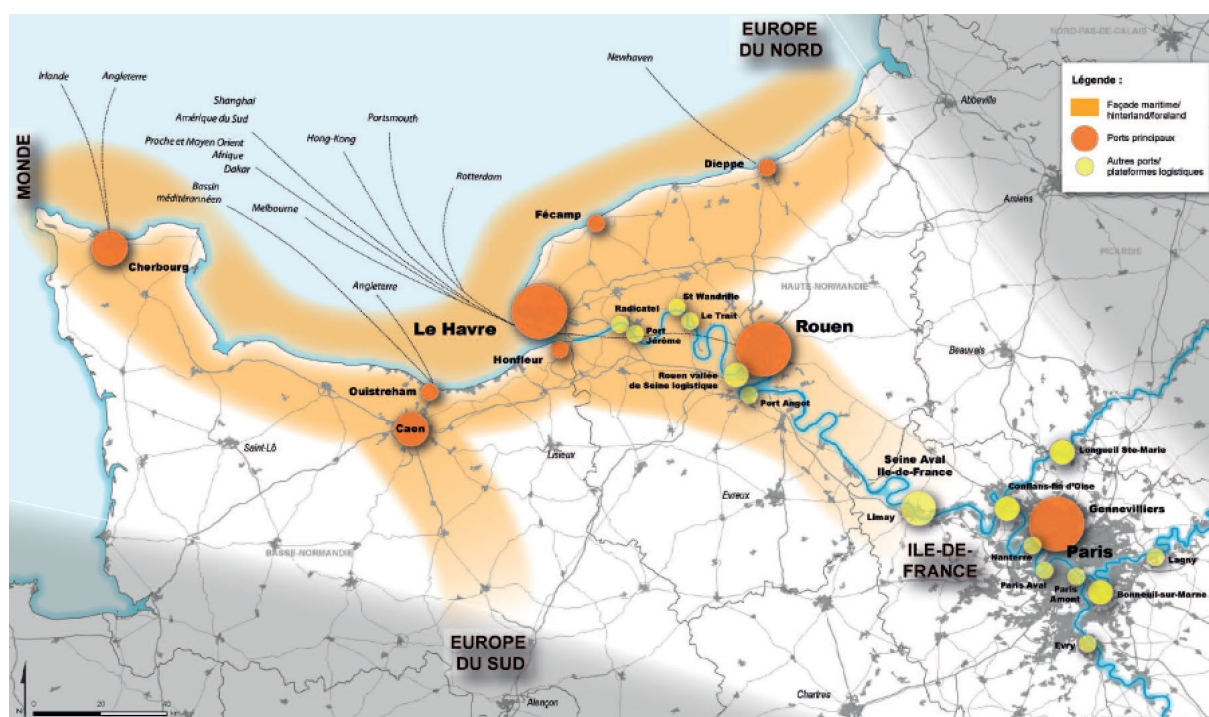


Figure 8 The Location of Rouen in relation to the port of Havre and the capital Paris. Source: Coopération des Agences d'Urbanisme, 2011.

In the territory of Seine-Aval, where Rouen is located, the climate is largely determined by its proximity to the maritime space and the relief of the Seine Valley.

The climate accord of the Métropole Rouen Normandie developed in coordination with the ADEME & WWF (2018) specified that between 1970 and 2017, an increase in average temperatures of +1.3 and + 1.9 ° C has been observed at the scale of the Metropolitan area of Rouen Normandie. Moreover, according to the analysis of weather simulations of Météo-France for the 'Seine-Aval territory' variations in climate conditions are foreseen on the horizons 2030, 2050 and 2080.

The evolution of climate in Rouen during the twenty-first century highlights various challenges in terms of vulnerability to climate change. Today, the city's location makes it susceptible to the impacts of climate change. As per EEA's classification presented in *figure 1* on key observed and projected climate impacts for the main regions in Europe (2017), this city is in the Atlantic region and is at risk of inundating due to the projected intensification in heavy rainfall events and the increase in river flows. It could also be at risk of amplified damages and increased vulnerability due to winter storms as well as climatic hazards.

4.1.1 Understanding the Impacts and Vulnerabilities: The "local IPCC", a Rouen-based climate scientific committee

Various studies have been conducted to develop an understanding of climate impacts and vulnerabilities in the region of Normandy. For instance, the exposure of Norman territory to the effects of climate change was presented in a technical report on 'climate adaptation' in the Upper and Lower region of Normandy developed by the General Secretariat for Regional Affairs (SGAR¹³) in 2013 at the request of the Inter-ministerial Delegation for Regional Planning and Attractiveness (DATAR¹⁴). The climate impacts and vulnerabilities on the region were also presented in the Regional Climate-Air-Energy Scheme (SRCAE¹⁵), which was developed by ADEME et al. (2013) following the approval of the regional council. Not to mention, other interregional and national projects highlighted the susceptibility of the region to weather events as well, such as the CLIMASTER research program conducted by National Institute of Agronomic Research and the Vulnerabilities of France against maritime flows (port activities) conducted by the European Strategic Intelligence Company.

According to these reports, the region of Normandy is vulnerable to rising annual average temperatures, hazard evolution in the light of climate change, increased intensity, and frequency of heatwaves, as well as the aggravation of episodes of drought.

The technical report on climate adaptation in the region developed by the SGAR of Upper and Lower Normandy (2013) underlined three major socio-economic challenges. It asserted that, first, climate change could impact economic security and the continuity of economic activities in the region of Normandy. Second, it could have effects on people's health and on the living environment, particularly during summers' heat waves. Third, climate change could have impacts on the resources of the territory.

¹³ Secrétariat Général pour les Affaires Régionales, France.

¹⁴ Délégation interministérielle à l'aménagement du territoire, France.

¹⁵ Schéma Régional Climat Air Énergie, France.

Sectors impacted by climate change in the region were also identified in this technical report (SGAR de Haute et Basse-Normandie, 2013), including, agriculture, construction and urban development, the physical infrastructure, environments and ecosystems, health, tourism, and water resources. In this context, it is however important to underline that an employee at the regional environmental agency of Normandy (interview, 2019) stated that the exposure and sensitivity of sectors to the impacts of climate change could vary within the region of Normandy given that the latter englobes heterogeneous types of territories both in terms of size and population (some municipalities are urban, others are rural). Thus, the importance of developing studies and assessment reports at sub-regional levels.

To present a more precise evaluation of the impacts of climate change on the region, the technical assessment presented by the SGAR of Upper and Lower Normandy (2013) has identified 6 types of territories, and vulnerabilities have been defined accordingly. The territory of Seine-Aval, stretching over the Seine valley from Rouen to the estuary, is presented as one of these 6 types. It is a corridor that has experienced major environmental risks such as heatwaves and superstorms. According to the report (SGAR de Haute et Basse-Normandie, 2013), these risks are not new and are worsening throughout the 21st century which increases the overall vulnerability of the territory, directly undermining the pillars of its economic development. The report also underlined that climate change has exacerbated these risks, by playing on a greater frequency of extreme episodes and a higher intensity of hazards.

According to the analysis of Météo-France's climate projections for the Seine-Aval territory, the evolution of climate parameters seems homogeneous in various parts of the area. The SGAR (2013), in its technical report, stated that the Seine-Aval territory is likely to witness an increase in annual thermal amplitude with a more rapid rise in average summer temperature (up to + 1.4 ° C by 2030, + 2.5 ° C by 2050, and + 4.5 ° C by 2080) compared to that of average winter temperatures (up to + 1.8 ° C in 2030, + 2.2 ° C in 2050, and + 2.6 ° C in 2080). The report presented that the exposure to heatwaves is expected to worsen rising from 0 to 5 days by 2030 and from 20 to 80 days on the horizon 2080 (considering the scenarios A1B¹⁶ and A2¹⁷). Moreover, a decrease in annual precipitation averages is anticipated, (up to -10% by 2050 and between -10 and -20% by 2080). A sharp decline of average summer precipitation is expected throughout the 21st century, ranging between -10 to -15% by 2030, -10 to -20% by 2050 and -20 to -30% by 2080. In this perspective, the exposure to episodes of drought is likely to increase significantly ranging from 20 to 35% of the time spent in drought by 2030, 30 to 50% by 2050 and 40 to 80% by 2080 (SGAR de Haute et Basse-Normandie, 2013).

The Territorial Energy and Climate Plan (PCET¹⁸), published by the city of Rouen in 2013, introduced the exposure of the urban territory to the impacts of climate change as deduced from regional assessments. It presented that, in the light of climate change the city is vulnerable to

¹⁶ The A1B scenario is an IPCC scenario in which the world relies on both combustible fossil fuels and renewable energies.

¹⁷ Scenario A2 is an IPCC scenario describing a world that remains divided. In the considered scenario, there is no redistribution of available natural resources, technological knowledge, and well-being between rich and poor regions.

¹⁸ Plan Climat-Énergie Territorial in France.

increased tension on water resources, the degradation of air quality, the erosion of biodiversity, an increase in inundation risks, and an increase in the intensity and the frequency of heatwaves. The PCET (City of Rouen, 2013) also underlined that the city is exposed to four major risks. On one hand, it is subject to the risks of transport of hazardous materials as well as technological risks (industrial accidents) related to the presence of many factories and industries in the region and in the Rouen port area. On the other hand, it is exposed to various natural risks such as the flooding of the Seine's banks, in addition to seismic risks around the St. Catherine Hill area.

However, it is important to underline that the exposures highlighted in the PCET mainly present direct consequences on the environment without elaborating on the socio-economic ramifications of these impacts. Also, the impact or vulnerability assessments presenting and analyzing current and future climate risks were not developed particularly at the scale of the city (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

After the affirmation of the Metropolis 'Rouen Normandy' in 2014 and in respect to the 2010 French Grenelle II law and the 2015 law on energy transition for green growth, a 'territorial plan for climate, air and energy' (PCAET) was developed and adopted by the Metropolitan Council on December the 16th, 2019. The PCAET was based on an 'Air-Energy territorial diagnostic report' developed by the Metropolitan area of Rouen Normandy (2017) presenting the vulnerability of the territory to climate change as deduced from SGAR's technical report (2013).

The PCAET developed by Métropole Rouen Normandie & COP21 (2018) affirmed that climate change is already perceptible and not only increases natural risks (i.e., flooding, drought, and forest fires) but also has ramifications on the economy due to the modification of touristic activities or changes in agricultural yields. It elaborated that global warming could have impacts on health and societies as heatwaves could increase the prevalence of certain diseases such as asthma. Lastly, it highlighted that the global issue could have repercussions on ecosystems and biodiversity relating to the capacity of species to adapt or migrate (Métropole Rouen Normandie & COP21, 2018).

The Metropolitan area Rouen-Normandie in partnership with WWF (World Wildlife Fund) France, developed the 'La Cop21 local' initiative to address climate change.

Under the presidency of Benoît LAIGNEL, 15 experts were asked to establish a local IPCC and bring a scientific approach around ten themes: climate, social psychology, water resources, agriculture, biodiversity, air quality and health planning and architecture, mobility and planning, energy, economics, and political science.

According to the local 'Rouen Climate Accord' (Métropole Rouen Normandie, ADEME & WWF, 2018), the aim of creating this local IPCC is to provide in-depth knowledge of climate change and its consequences on various sectors at a local level, to develop appropriate adaptation solutions. The first works of the local IPCC during the year 2018 have allowed to improve the understanding of the evolution of the climate as well as the challenges faced by local populations (Métropole Rouen Normandie, ADEME & WWF, 2018). The local climate accord clarified that the establishment of this unit, bringing together various experts, is seen as crucial as there are almost no studies done at this scale.

Interviews revealed that environmental experts and scientific researchers working on the topic at the heart of the city of Rouen and the metropolitan area of Rouen are aware of some of the impacts of climate change on their territory and they are trying to improve and dissipate this

knowledge. Officials at the metropolitan level highlighted that there is a good level of knowledge at a national level, a less developed one at a regional level and a weak understanding of impacts at a metropolitan or a local scale (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). A climate researcher at the University of Rouen stated in an interview (2019) that there is still a need to conduct more research and to do climate modeling to improve the understanding of climate repercussions at a local scale as the current comprehension of impacts is based on studies conducted at the regional level in 2012 and 2013. Nonetheless, he asserted that the establishment of the local IPCC is a steppingstone for developing that research and understanding yet explained that it is not enough; financial, technical, and human resources need to be made available to improve the understanding of climate ramifications at a local scale (Climate researcher at the University of Rouen, interview, 2019). Not to mention, the research conducted by the local IPCC is at the scale of the metropolitan area (which includes 71 communes) and is not particular to the city of Rouen. The city of Rouen has no current plan to developing its own impact assessment (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

The 'Rouen Climate Accord' (Métropole Rouen Normandie, ADEME & WWF, 2018) indicated that despite the efforts to raise awareness, develop impact assessments and strategies, and communicate them, the awareness of citizens is insufficient with regards to the gravity of the impacts and their consequences on their daily lives.

Lesconnec (2017), in its sustainable development annual report presented to the municipal council, indicated that at the end of 2015, a telephone survey was conducted among 400 inhabitants representing the population of Rouen. The survey revealed that the citizens still have difficulties in defining the notion of sustainable development even if it is familiar to them. This notion has an environmental connotation that to the inhabitants is often limited to the issues of sorting and recovery of waste.

In Rouen, people are progressively becoming familiar with the issue of climate change. A climate researcher at the University of Rouen (interview, 2019) highlighted that the interest of elected mayors as well as local citizens in climate change is not the same as it was 10 or 15 years ago. He explained that people are becoming more interested in, or at least familiar with, problems related to the environment. As a case in point, a press article (Durand-Gratian, 2019) asserted that on Saturday, March the 16th, 2019 around 2000 people gathered to defend climate action in the streets of the Norman capital in the context of the global climate change protest. However, an employee at the city of Rouen (interview, 2019) stated that more effort is needed to engage the public and raise their awareness on the impacts that climate change is having on their city, health, economy, and respective adaptation options.

The 'Rouen Climate Accord' (Métropole Rouen Normandie, ADEME & WWF, 2018) specified that the year 2018 marks an important year for the development of the climate plan as the local Cop21 organized various events and worked on raising awareness around the issues of the ecological transition. An employee at the Métropole Rouen Normandie at the directorate of environment and energy (interview, 2019) indicated that a physical workshop was established at the heart of the city of Rouen, known as the "atelier cop21" serving as a "vitrine" to communicate the efforts conducted by the local government in the context of the local COP21 (*figure 10*). He explained that the atelier offered a physical place for exchanging knowledge, and organizing activities and exhibits

on various themes related to climate change such as the bleaching of coral reefs, air quality, transport, etc. However, the physical space of the atelier COP21 closed its doors at the beginning of June 2019 as anticipated, after being there for a year and a half, given that this place was only meant to exist for a limited period to launch the local COP21 initiative, affirmed the Métropole Rouen Normandie employee at the directorate of environment and energy (interview, 2019), asserting that “financial constraints didn’t allow for this workshop to endure longer than anticipated”. However, he clarified that the initiative will still exist, not as a physical atelier, but rather as regular workshops that are done in various parts of the metropolitan area at the request of communes and associations.



Figure 10 The Atelier Cop21 physical workshop which was established at the heart of the city of Rouen by the Metropolis to communicate on climate and environmental initiatives and raise awareness. Photo taken in May 2019, before it closed its doors.

Reports and published studies on different scales allow to develop an understanding of the impacts of climate change on the territory as well as their socio-economic ramifications. However, most reports are rather general as they focus on a regional or a metropolitan level and are not specific to the city of Rouen. These reports elaborate on impacts that are already being dealt with such as the UHI effect in cities, heatwaves, heavy storms, and flooding but there is not much information on the risks of the lack of water availability. Not to mention, the municipality has not really developed any environmental or climate studies at the scale of the territory.

Heatwaves and UHI effect

The technical assessment presented by the SGAR of Upper and Lower Normandy (2013) specified that the territory of the Seine-Aval is not as exposed to heatwaves as the fringes of Paris due to the proximity of the sea and the penetration of the maritime influences by the valley of the Seine. However, the vulnerability to this effect of climate change is not negligible given that the Seine-Aval is the most urbanized territory in the Normandy. The region's very dense urbanization makes it susceptible to the reduction in summer thermal comfort, both in terms of quality of life and health (SGAR de Haute et Basse-Normandie, 2013).

In an interview, a climate researcher at the University of Rouen (2019) stipulated that the heatwaves and increased temperatures are among the impacts that are currently being the most sensed in Rouen. He explained that these manifestations are expected to increase in frequency and in intensity in the light of climate change. An employee at the Regional environmental agency of Normandy (interview, 2019) outlined that it is not likely, with the maps developed at the scale of regional and metropolitan studies, to precisely evaluate the prominence of the UHI effect in the city of Rouen, which depends on many parameters including the density of population, the concentration of artificialized surfaces, the urban morphology and heat emissions in urban areas. The 'Air-Energy territorial diagnostic report' developed by the Métropole Rouen Normandie (2017) stated that the future vulnerability to the UHI effect in this city can't be anticipated as it depends on the evolution of these different parameters which makes urban planning choices extremely important as they affect the city's vulnerability. This underlines the need for developing urban heat island maps and climate risk analysis at the scale of the city of Rouen.

A climate researcher at the University of Rouen (interview, 2019) stated that a research study has been conducted to improve knowledge related to this impact through analyzing NASA satellite images of surface temperatures which allow to identify areas and sites that need to be given attention to. He, however, explained that there is still a need to intensify and focus this research.

The SGAR's (2013) technical report, presenting the vulnerability of the Lower and Upper Normandy region to climate change, indicated that certain populations in Rouen including the elderlies, people with illnesses, young children, and people with low incomes, could be particularly susceptible to an increase of mortality rate due to deadly heatwaves. It specified that transport networks and urban areas emit more or less high amounts of air pollutants which are likely to be more condensed during heatwaves, directly affecting the health of susceptible and sensitive populations. The technical report (SGAR de Haute et Basse-Normandie, 2013) also stated that the increase in the intensity and the frequency of heatwaves is likely to affect the thermal comfort of public transport users in the urban space (bus, tramway, etc.) and between cities (rail network). Not to mention, an increase in average summer temperatures is likely to result in a surge in energy consumption in summer because of a growing need for cooling and air conditioning. An employee at the municipality of Rouen (2019) indicated in an interview that the city is particularly vulnerable as it is at the center of a topographic depression favoring the concentration of pollutants in periods of heatwave, especially that it concentrates heavy polluting industries.

According to the SGAR report (2013), the 2003 heatwave presents an example of this impact as it was more strongly felt in Rouen than in other areas in the Normandy. Impacts were relatively more significant in the city center as the UHI effect accentuated the gravity of the heatwave. That year, the average daily maximum temperatures in summer (from 1 June to 30 September) increased by

almost 3 °C in Rouen in comparison to the average of the previous summers (SGAR de Haute et Basse-Normandie, 2013).

A press article (Verdun, 2019) indicated that in July 2019, Rouen's maximal temperature reached 41.1 °C beating its 2003 record of 38.1°C. Also in 2020, the city faced another heatwave and temperatures reached 38.4 °C (Valerio, 2020). The situation is alarming as new records and heatwaves are becoming more recurrent expressed the Climate researcher at the University of Rouen (2019) in an interview. City officials highlighted that particularly in the event of heatwaves people become more alerted to the question of climate change because they are not accustomed to high temperatures (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

Heavy Storms and Flooding

The regional assessment report developed by the SGAR (2013) indicated that in the perspective of climate change, the evolution of the heavy rainfall events responsible for flooding seems relatively uncertain. However, the Normandy region is most likely to witness an increase in the frequency and intensity of extreme weather events including floods and heavy storms which could lead to a domino effect in the event of crisis impacting the physical infrastructure as well as various economic sectors. The episodes of heavy rainfall, in a context of strong artificialization of the soil, leads to considering a possible aggravation of the risk of flooding by runoff (SGAR de Haute et Basse-Normandie, 2013). The highly urbanized territory of the Seine-Aval presents a high current vulnerability to this risk as the impermeability of soils favors rainwater runoff and their accumulation in low points. Consequently, the risk of flooding during periods of heavy rainfall is particularly important in urbanized territories including Rouen (SGAR de Haute et Basse-Normandie, 2013).

In the past years Rouen experienced various inundation events, these events are however expected to increase in frequency and intensity due to climate change. As a case in point, a press release (Blavignat, 2016) showed that in June 2016, the Seine River submerged the medieval city of Rouen obstructing traffic. Similarly, In February 2018, and in March 2020 the docks of the Seine River flooded, and the navigation of boats was suspended (Normand, 2020).

Flooding is an environmental event that is seriously taken by inhabitants asserted a Regional environmental agency of Normandy employee (interview, 2019), elucidating however that "it is rather considered a natural event and not often seen as an impact of climate change".

The future vulnerability to runoff flood risk in Seine-Aval will depend largely on the ability to control land use and storm-water management in urban areas, in a context likely to continue the demographic growth asserted a climate researcher at the University of Rouen (interview, 2019). It remains difficult, at the scale of existing interregional studies, to specify locally the vulnerability of the different urban areas and industrial sites to the sea-level rise. The SGAR technical assessment (2013), however, suggests a significant increase in the vulnerability of the Port of Rouen and urban developments at the proximity of the Seine to submersion episodes in the light of sea level rise, which is likely to have further ramifications on the economic and industrial activities (SGAR de Haute et Basse-Normandie, 2013).

The local IPCC (GIEC LOCAL) developed a report on water resources and flood risks in Rouen Normandy Metropolis and presented maps underlining the inundation risk due to overflowing

watercourses and risk of flooding by runoff (*figure 11*) (Kazmierczak, Laignel, & Charrier, 2019). The map shows a particular vulnerability of the territories adjacent to the Seine watercourse. However, as the mapping is zoomed out to cover the scale of the metropolitan area (including 71 municipalities), the vulnerability of the city of Rouen to flood risks does not seem clear.

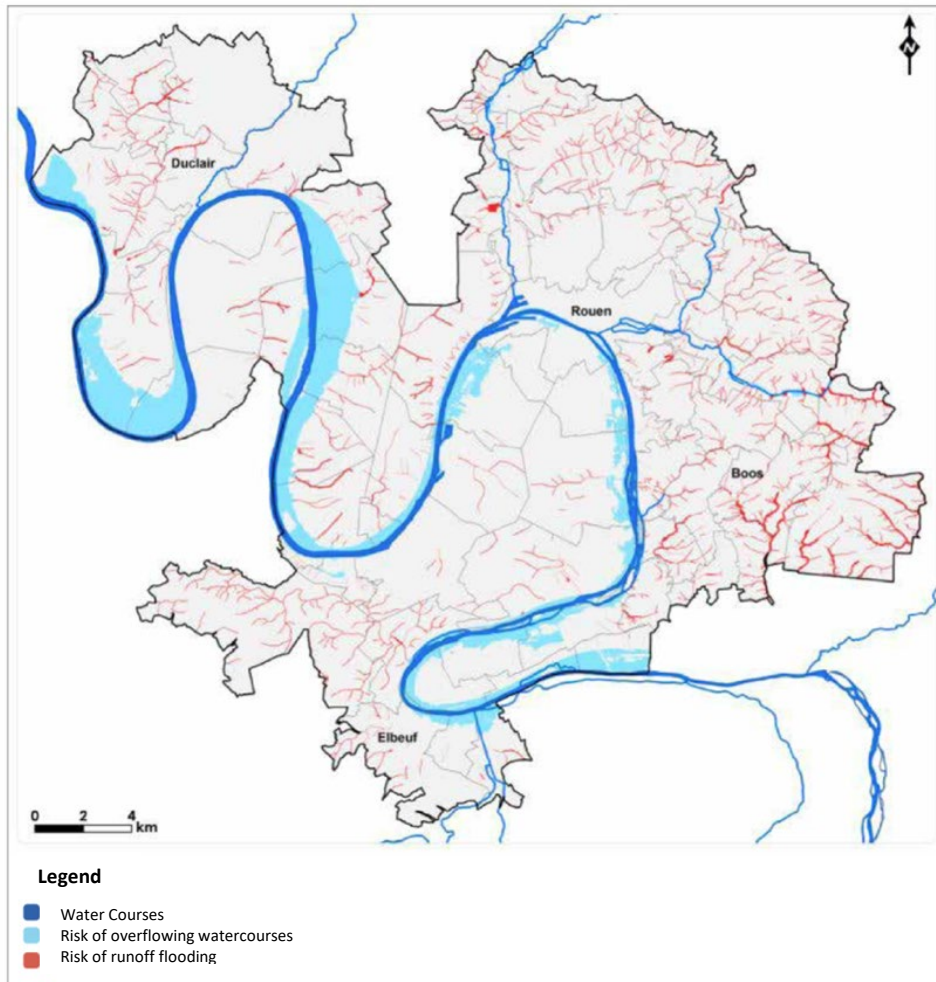


Figure 11 The inundation risk due to overflowing watercourses and risk of flooding by runoff. Source: Kazmierczak, Laignel, & Charrier, 2019.

Droughts and Reduced availability of water resources

The SGAR technical report (2013) specified that water resources in the Seine-Aval are strongly solicited, by industries and the need for drinking water, yet the territory is currently little affected by the reduced water availability.

However, the 'Air-Energy territorial diagnostic report' developed by the Metropolitan area of Rouen Normandy (2017) stated that the projected increase in the frequency and intensity of dry periods in the context of climate change is expected to decrease the recharge of the main aquifers. According to the diagnostic report (Métropole Rouen Normandie, 2017), the average deficit overall simulated aquifers is estimated at 2200 Mm³ / year in 2050, and 2700 Mm³ / year in 2100. The situation will thus increase the stress on water availability and is likely to create tensions between agricultural, domestic, and industrial usages of underground water (Climate researcher at the University of Rouen, interview, 2019).

4.1.2 Developing Adaptation Strategies: Overlap of strategies, a lack of coordination between different levels of governance

In 2006, a national climate adaptation strategy, setting broad guidelines was established. The inter-ministerial group submitted a report in 2009 highlighting that climate change could cost several billion euros per year in various sectors if no adaptation measures are put in place. These different works served as a basis for the national adaptation consultation which took place in 2010, resulting in more than 200 recommendations at the national level (Lukat et al., 2016).

The first National Adaptation Plan (NAP) (2011-2015), published in 2011 as required by the 2009 law¹⁹, identified the measures that should be implemented at the national level and the actions that should be addressed at regional levels (Lukat et al., 2016). An evaluation of the national plan (Caude et al., 2015) was developed, reinforcing the importance of focusing adaptation measures on regional levels. Moreover, a second NAP (2018-2022) was presented in December 2018 to strengthen the strategic management of the adaptation approach through collaborating with territorial levels of governance, including local actors and civil society (Lenormand, 2018).

The technical report developed by the General Secretary of Regional Affairs (SGAR) of the Upper and Lower Normandy region in 2013 presented adaptation guidelines for each defined territory in the region, including the territory of Seine-Aval where Rouen sits. In addition to specific orientations, proposals were developed to be common to the entire region.

Proposals that are common to all territories in the region of Normandy embraced ensuring coherent management of water resources as well as ecological continuities in spatial planning (green and blue infrastructure systems) which allow for the evolution of biodiversity (SGAR de Haute et Basse-Normandie, 2013).

The SGAR (2013) proposed three major adaptation proposals specific to the territory of Seine-Aval where Rouen lies.

First, the territory was recommended to make the valley of the seine a place for experimentation and development of the bioclimatic city, defined by the SGAR (2013) as a city where constructions are focused on reducing energy consumption and regulating indoor thermal comfort. This orientation concerns more particularly urban areas in the Seine-Aval including the city of Rouen. The concept refers more globally to the place of Nature in the city and the quality of the urban living environment.

Second, the technical report (SGAR, 2013) suggested that the Seine-Aval territory could work on maintaining and strengthening economic activities along the seine valley and adapting the infrastructure to the impacts of climate change.

Third, it has been suggested to orient territorial planning in Seine-Aval to increase the resilience of the area to impacts of inundation (SGAR de Haute et Basse-Normandie, 2013). More concretely, through managing and dealing with existing risks, ensuring the robustness of the existing buildings, and prioritizing the development and new constructions in zones that are not exposed to risks of inundation.

¹⁹ Law No. 2009-967 of August 3, 2009, on programming relating to the implementation of the Grenelle de l'Environnement.

On the 5th of November 2015, the Seine-Normandy Basin Committee (2015) adopted the Master Plan for Water Development and Management (SDAGE²⁰) which reflected on new challenges including the foreseeable effects of climate change. Floods are dealt with in the Flood Risk Prevention Plan (PPRI²¹), which contains a common part with the SDAGE. The orientations of the SDAGE aim at driving major stakeholders towards ambitious and realistic goals and include proactive actions to protect and reclaim drinking water, the restoration of the ecological continuity of rivers, and the development of local management policies around territorial public institutions.

The NAP (2011-2015) as well as the established environmental laws defined the role of local authorities in addressing environmental and climate issues and required local and regional governments to take climate actions.

The Grenelle II²² law (Article 75) made the development of a Regional Climate-Air-Energy Scheme (SRCAE) mandatory. Moreover, this law required the development of the Territorial Climate-Energy Plan (PCET) for communities and cities with more than 50 000 inhabitants²³.

Also in 2015, a law relating to the energy transition for green growth²⁴ was established requiring communities with more than 20,000 inhabitants to develop a 'territorial plan for climate, air and energy' (known as PCAET²⁵), integrating the notion of "air" into the PCET to emphasize air quality.

In response to the Grenelle II law, the region of Haute Normandie developed the SRCAE which was published in March 2013. The regional plan highlighted that it does not set quantitative targets for adaptation but recommends the region of Upper Normandy to develop a regional adaptation strategy. The SRCAE (ADEME et al., 2013) considered that setting precise targets is a challenge given that there is a high uncertainty to changes of climate particularly on long-term horizons as the severity of impacts would depend largely on the mitigation measures implemented globally. Moreover, it stated that the translation of global scenarios at a local scale and the response of local ecosystems to climate disturbances are in many sectors difficult to model.

The city of Rouen has also endorsed the role of the local coordinator of energy transition in response to the Grenelle II law through the development of its PCET in 2013 (City of Rouen, 2013) which served as a continuity of its agenda 21 "My city is my planet" (City of Rouen, 2011). Furthermore, the City of Rouen undertook a second action plan for its agenda 21 in 2017 to address the challenges raised by the first action plan, to raise new challenges and to reinstate its commitment to the ecological transition. An employee at the municipality of Rouen (interview, 2019) stated that despite the increased sensitivity to environmental matters and efforts to take action, many at the municipal council, still lack the awareness or are not pushing for an environmental agenda at a local scale.

²⁰ Schéma Directeur d'Aménagement et de Gestion des Eaux.

²¹ Plan de Prévention des Risques d'Inondation.

²² Law n° 2010-788 of July 12, 2010, a French national commitment for the environment which supplements, applies and territorializes the "Grenelle 2 Law".

²³ The first version of the PCET needed to be submitted by the end of year 2012. Other local authorities, with less than 50,000 may also establish a PCET on a voluntary basis.

²⁴ Law no 2015-992 of 17 août 2015. This law fixes new intermediary on the horizon 2030 (reduction of GHG emissions by 40%, reduction of energy consumption by 30% and increasing the share of renewables to reach 32% of the total energy consumption) (Métropole Rouen Normandie & COP21, 2018).

²⁵ Plan Climat Air-Énergie Territorial in France.

The city of Rouen's agenda 21 set in 2011 and further integrated into the PCET, presented 6 main goals for the city. These goals are (1) Addressing climate change, (2) Preserving biodiversity, the environment, and resources, (3) Ensuring social cohesion, solidarity between territories and generations, and the fight against discrimination, (4) Ensuring the prosperity of everyone, (5) Promoting and developing responsible consumption and production models, (6) Developing the exemplarity and the driving ability of the city. For each goal, the agenda 21 (City of Rouen, 2011) highlighted the main partners, the challenges related to reaching this goal, the objectives to be reached by 2020, assessment tools as well as existing indicators and indicators to be developed, and examples of implemented and planned projects.

To reach those goals, 17 challenges were raised, and 7 among them were considered a priority, including (1) transportation, (2) the energy efficiency of the built environment, (3) the valorization of biodiversity in urban environments, (4) the wellbeing of everyone, (5) the cleanliness of the city, (6) sustainable food supply and (7) information, raising awareness and the participation of locals. The agenda stated that the city is keen on making further progress in the sustainable management of green spaces, on developing new green spaces to create ecological corridors, and offering residents shared gardens. Moreover, the city raised the question of preserving the 150 hectares of natural and wild environments present on the territory. The city's agenda 21 (City of Rouen, 2011) highlighted the importance of sharing information, spreading awareness, and ensuring the participation of various stakeholders. Therefore, it stressed that it is aiming at strengthening public consultation and ensuring the co-construction of public policies. It is nonetheless important to emphasize that the local agenda is focused on sustainable development and addressing climate change is only 1 goal out of 6. Not to mention, the challenges raised are rather concentrated on energy efficiency, climate mitigation actions as well as increasing the city's livability.

Nonetheless, the PCET developed by the city of Rouen (2013), serving as a continuity of the local agenda 21, defined energy-climate strategies basing its action program on three major axes:

- "Mitigation" which aims to improve energy efficiency, increase energy production renewable energy, and reduce GHG emissions,
- "Adaptation" to prepare the territory to face the unavoidable impacts of disruption climate,
- "Raising awareness" which involves mobilizing local actors.

The PCET (City of Rouen, 2013) shed light on the city's adaptation ambitions which aim on increasing the share of greenery by 2020 and strengthening flood risk prevention. An action plan is also developed, in the context of the PCET, highlighting the actions to be taken, the implementation status, and the deadline for developing the action (City of Rouen, 2013). However, the action plan does not include medium- and long-term adaptation plans (to be implemented after the year 2020) and is only concentrated on short-term adaptation actions.

After the formation of the metropolitan area of Rouen, and with respect to the law on energy transition for green growth, the metropolis developed a 'Climate-Air-Energy Territorial Plan' (PCAET) (Métropole Rouen Normandie & COP21, 2018). The climate-air-energy plan, common to all 71 communes forming the metropolitan area (including the city of Rouen), introduced operational actions and implementation of guidelines decided at the regional level allowing for an ecological transition. It is important to mention that the metropolis surpassed the legal obligations of developing a PCAET as it took the initiative to establish a local COP21, to form a local IPCC (GIEC local) and to develop a 'Rouen climate accord'.

In an interview with a 'Métropole Rouen Normandie' employee (2019), he explained that the PCAET was built up gradually and enriched throughout its development. After developing the diagnostic report, the metropolis realized that it could not act alone to address climate issues, thus the 'Local COP 21' initiative was founded in partnership with ADEME and WWF France. The objective of this initiative was to mobilize all players of the territory.

This territorial dynamic allowed for the definition of a 'Climate-Air-Energy' policy that was adopted on October 8, 2018, by the Metropolitan council. The Rouen climate agreement also played an important step in the process as it ensured the mobilization of various stakeholders. In 2019, the metropolis worked on strengthening consultation around the PCAET to enrich its policy.

The two interviewed officials at the municipality of Rouen asserted that they weren't consulted and didn't take part in the elaboration of the PCAET, even though the municipality of Rouen represents the most populous municipality of the Metropolis. The city of Rouen thus engaged itself to develop its proper climate-air-energy plan (2017-2021) independently from the one developed at the scale of the metropolitan area. This demonstrates the low level of coordination between both levels of governance. Nonetheless, the metropolitan invited various actors of the territory to sign the Accord of Rouen as part of its COP21 initiative, and the city of Rouen took part of this initiative and presented various engagements.

Both the climate air plan developed at the scale of the city and the metropolis include objectives in term of adaptation to climate change, but are rather focused on sustainable development, mitigation measures (GHG emissions) and air quality.

The Climate-Air-Energy Action Plan (2017-2021) specific to the city of Rouen, was developed in parallel to the PCAET and presented at the municipal council on April 9, 2021 (*refer to appendix II - table 6*). It encompassed 37 actions, organized, and laid out based on 3 levels of priority (high, medium, and low priority). The graph below (*figure 12*), presenting the actions of Rouen's climate-air-energy-action plan per level of priority and purpose, shows that there is a dominance of measures dedicated to mitigation, air pollution and sustainable development. Also, adaptation actions are among the ones with a lower priority level. 9 actions out of 37 are considered as the ones with a top priority among which at 8 are focused on energy management (mitigation/air pollution). The actions that are classified as having a secondary order of priority include accompanying the Metropolis in the implementation of the action plan "Breathing Cities" and supporting the development of urban gardening and all forms of greening. Actions that are classified as having a tertiary order of priority include continuing the restructuring of urban green spaces (parks, gardens, ...) and the implementation of the differentiated management plan for these spaces as well as preserving the water resource and reducing the city's drinking water consumption.

Figure 12 demonstrates that the Climate Action Plan (2017-2021) developed by the city of Rouen is emphasizing and prioritizing energy management and considers key elements to adaptation, such as urban greening and the preservation of water resources, as having a secondary or a tertiary order of priority.

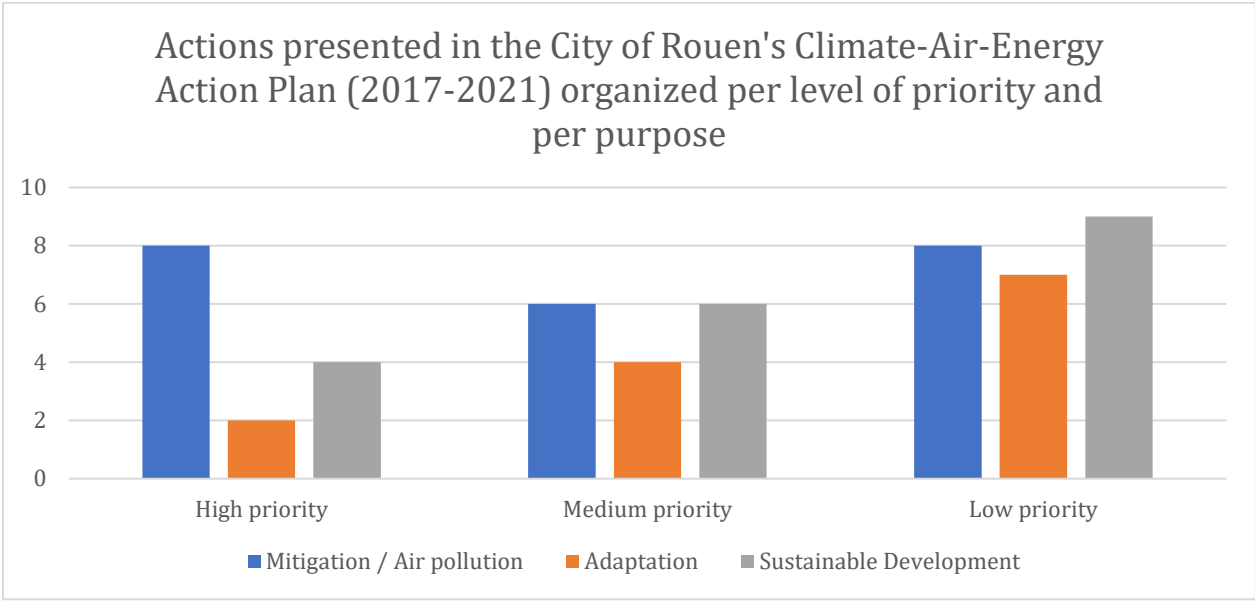


Figure 12 Types of measures presented in the City of Rouen's Climate-Air-Energy Action Plan (2017-2021).

While meeting with the employees working on this matter at the municipal level, they have affirmed that the city aims at establishing an action plan for adaptation in the framework of its commitment to the 'Mayors adapt' initiative and renew the Cit'ergie action plan (the continuation of uncompleted actions and the development of new actions). The city was initially aiming on completing this action by 2018, however, to date no adaptation action plan has been developed due to delays because of the shortage in human resources working on this matter, political changes at the municipality in the light of the elections and changes in priorities because of the covid 19 pandemic (Municipality of Rouen employee in charge of ecological transition, interview, 2021).

The Métropole Rouen Normandie's PCAET reinforced the plan to reduce GHG emissions, improve air quality and adapt to climate change for the years 2020 and 2050 (Métropole Rouen Normandie, 2017). Consequently, 40 actions were defined by the PCAET to be implemented between 2019 and 2024 (refer to appendix II-table 7) among which 87.5% include mitigation targets, 82.5% embrace the improvement of air quality, 52.5% elaborate on the increase of the share of renewables and only 35% present actions that increase the adaptability of the territory (figure 13).

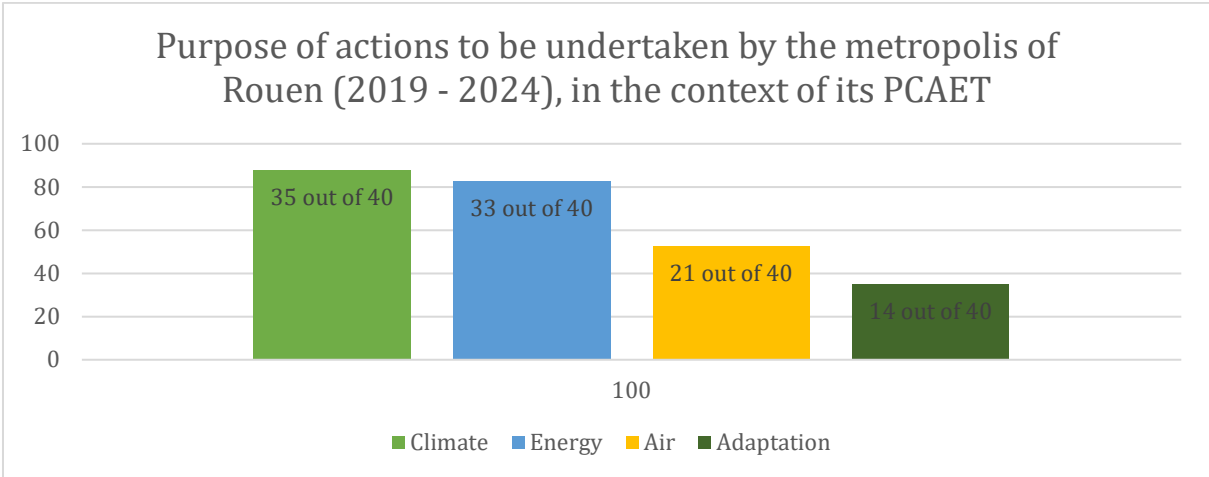


Figure 13 Purpose of actions to be undertaken by the metropolis of Rouen (2019 - 2024), in the context of its PCAET.

However, as this thesis concentrates particularly on adaptation measures, it will only examine the actions that are developed to adapt the territory and increase its resilience to climate events.

Various commitments are made by the Metropolis of Rouen Normandy, in the context of its PCAET, to adapt the territory.

The PCAET developed by Métropole Rouen Normandie & COP 21 (2018) presented the metropolis' ambition in promoting sustainable urbanism and guaranteeing the protection of the natural environment through its local inter-communal urban plan (PLUi²⁶). It also identified its objective to analyze the impact of heatwaves on UHI effects, strengthen data on UHI in partnership with the University of Rouen, reinforce knowledge on the impacts of climate change on water resources and flood risks and raise awareness. To preserve water resources, the metropolis of Rouen Normandy stated in its PCAET (Métropole Rouen Normandie & COP21, 2018) its objective of improving the performance of wastewater treatment plants to reduce the impact of urban waste on the quality of the water. The metropolis has also set itself the goal to maintain the policies in place to protect the city from flooding given that Rouen has been recognized as a High-Risk Flood Area (Territoire à Risque Important d'inondation-TRI) under the European Flood Directive²⁷ (2007) since 6 November 2012.

Some of the measures that are set in the PCAET to primarily mitigate climate change also ensure a better adaptability of the territory's infrastructure. As a case in point, the metropolitan area considers that the renovation of existing housings is a key issue for the energy transition. This ambition will concretely translate into a progressive increase in the number of renovated dwellings as the Métropole Rouen Normandie have stated in its 'Climate Accord' (2018) that it is expected to renovate 45,000 unit by 2030. Nonetheless this measure also increases the adaptability as the renovation of housings could improve the overall thermal comfort of residents.

In the case of the city of Rouen as well as the Métropole Rouen Normandie, no specific adaptation strategy or plan, with specific objectives and targets, has been developed. However, some adaptation policies have been included in the air-climate-energy plans which are rather focused on sustainable development and the ecological transition in general. Mitigation actions and ambitions seem to be more numerous, elaborated, and defined in comparison to proposed adaptation measures which seems to lack specific targets or defined timeframes or deadlines. Nonetheless, the proposed adaptation measures at both levels of governance corresponds to and addresses the environmental impacts that are observed in the area including heat waves and UHI effect, flooding, and heavy storms as well as droughts and decrease in water availability.

The timeline below (*figure 14*) illustrates that the development of an environmental and climate strategies and laws at a national level has induced climate action at a regional and local level. The establishment of a national adaptation strategy and the creation of the Grenelle II law preceded the development of a regional climate plan in the area of Normandy and a local climate plan for the city of Rouen. This shows that, in this case, subnational governments are rather reactive and not proactive when it comes to climate action. This example portrays a top-down approach to climate adaptation governance. Also, the city of Rouen adopted its agenda 21 in 2011 to declaring

²⁶ Plan local d'urbanisme intercommunal.

²⁷ Directive 2007/60/ EC. This Directive requires the development of flood risk management plan, based on an assessment considering the effects of climate change on "the occurrence of floods" and integrating the consideration of events whose probable return period is greater one hundred years old.

its intention in assuring sustainable development at a local scale, almost 2 decades after the Rio summit (1992) which presented the agenda 21 embracing actions taken in various areas at different levels of governance to limit human impacts on the environment.

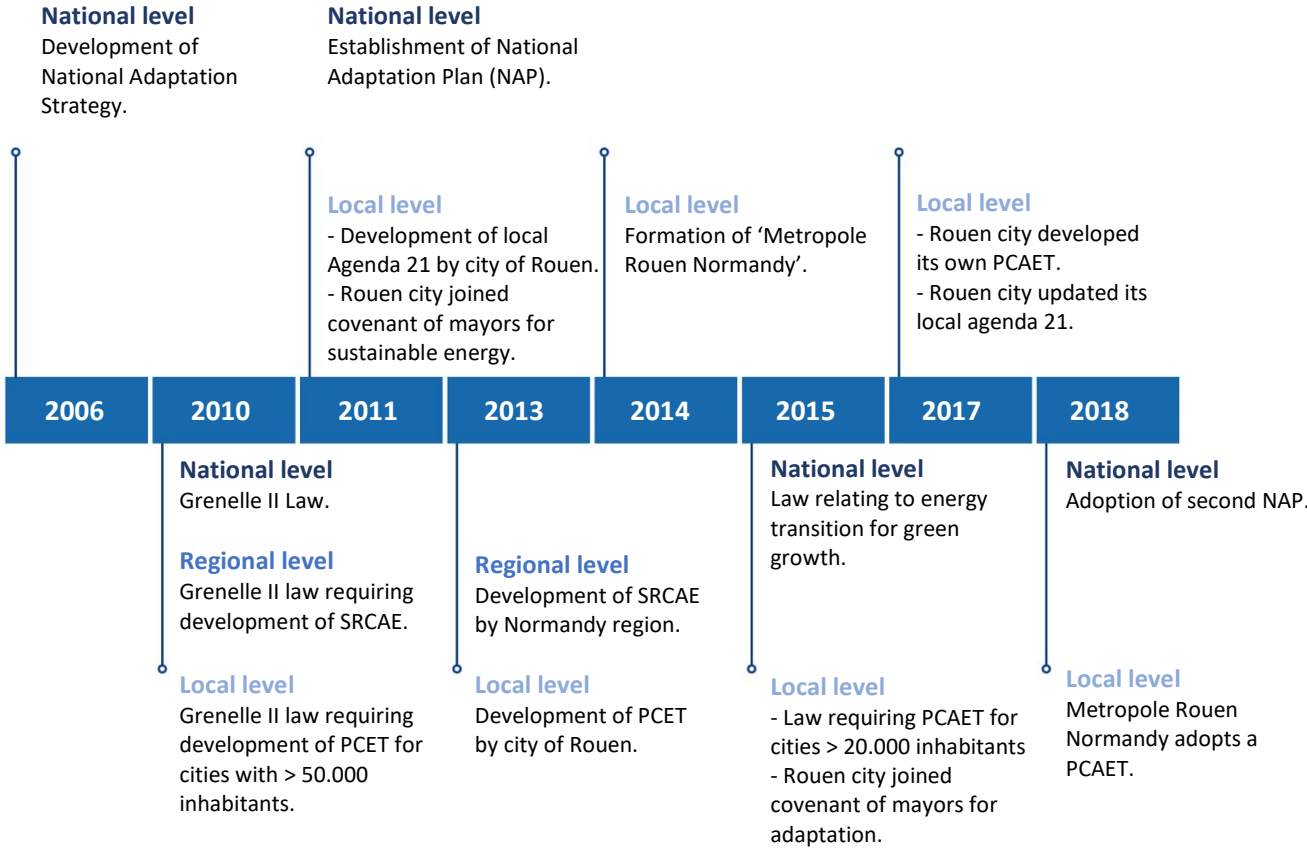


Figure 14 Timeline of strategy development at a national, regional, and local scale serving climate adaptation in Rouen.

4.1.3 Implicating and Mobilizing Actors: Efforts towards a participatory approach opposed by the lack of synergies across city departments

France has a centralized, top-down culture of policymaking (Samuel, 2017). FRANE, a French environmental conservation organization, specified in its factsheet no.5 that in environment and sustainable development, the responsibilities of governmental actors are mainly framed by the general code of local authorities and environmental code. The factsheet (FRANE, 2015) asserted that in recent years, decentralization efforts and laws have been gradually assigning more competencies to local authorities. It presented the competencies of different levels of governance as follows:

Regional French authorities have important competencies in land use planning, the preparation, and the revision of the regional and sustainable development plan.

Departments do not have many “duties” in environmental management but hold the responsibility to manage the natural sensitive areas and forests by making an inventory of sensitive sites deserving special protection and taking appropriate actions to assure their preservation.

The metropolitan areas (e.g., metropolitan area of Rouen Normandy) have important competencies in matters of water and sanitation, waste management, air pollution as well as environmental and energy management.

Local municipalities or communes have competencies at a local scale in areas such as territorial planning, development of transportation systems, social action, schools, waste collection, and sanitation²⁸ (FRANE, 2015).

Rüdinger (2018) asserted that the French experience illustrates how the progressive integration of various actors and independent experts can have an effect when dealing with organizational conflicts, ensuring a more inclusive policy development.

Rouen participated in the Interreg IVB-Project Future Cities – urban networks and hosted the “Future Cities” conference in 2009 on the topic of climate adaptation. The conference’s discussion underlined the importance of creating European partnerships.

“With respect to its fields of competencies, the city of Rouen decided to ensure a sustainable development of the city” stated an employee at the municipality of Rouen in charge of ecological transition (2019) in an interview. He explained that the city council first adopted its agenda 21 in 2011 as ecologists at the heart of the municipality pushed for it and the city had the willingness to act. The agenda described different aspects of the city’s public policy and was set in collaboration with an external cabinet of skilled experts which “with objectivity, indicated points of strengths and points of weaknesses and defined global objectives” (Municipality of Rouen in charge of ecological transition, interview, 2019).

The contributions of the Rouennais Council of Sustainable Development constituted of around 40 members of civil society and of the inhabitants, helped define the strategy (goals and challenges) and the framework of its Agenda 21 (structuring, action plan, concrete proposals). This framework has been included in the PCET (City of Rouen, 2013) and is regularly enriched by actions proposed by the inhabitants via the city’s website²⁹ which allows them to share their opinion and knowledge. Nonetheless, after re-evaluating the first action plan of the agenda 21 city officials decided to abandon the ‘Council of Sustainable development’ as it proved to be inefficient. For the development of the second action plan of the local Agenda 21, the city of Rouen made the choice to listen to the proposals of the agents and local citizens, as part of a series of workshops entitled “Pause Verte” which translates into “Green Break”. These brainstorming sessions brought together around sixty municipal officials and a dozen of citizens who voluntarily wished to participate. It aimed at prioritizing the actions in progress which not only should address the challenges of sustainable development, but also must illustrate the commitment of the city and promote the transversality of approaches and integrated approaches (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019).

The city’s PCET (2013) clarified that the agenda 21’s piloting Committee, which was established by the deliberation of the Municipal Council on the 16th of May 2008, remains the guarantor of the implementation, the evaluation, and the revision of the local climate-energy-territorial plan every five years. This committee guides the process in accordance with the principles of Sustainable Development and ensures that the overall coordination is maintained. It brings together, once, or

²⁸ This competency can be transferred to a mixed union (syndicat mixte) based on the request of the municipality.

²⁹ <https://www.rouen.fr/>.

twice a year, elected officials, services, and the main institutional partners of the city: the DREAL, the Normandy Region, the Metropolis ROUEN Normandie, and the ADEME.

The city of Rouen's commitment to take climate action is reflected in the signature of the Covenant of Mayors "for a sustainable local energy" in October 2013 and the Covenant of Mayors for "adaptation" in 2015. Both commitments form a single Convention "For Climate and Energy". This adhesion portrays the local government's voluntary commitment to meeting and exceeding the climate and energy targets set by the EU. Rouen, as a signatory city, pledged to limit its GHG emissions and strengthen the resilience of territories to the effects of climate change. It also agreed to increase cooperation with other local and regional authorities in the European Union and beyond through the exchange of knowledge and best practices, to improve access to safe, sustainable, and affordable energy (Lesconnec, 2017).

The city is also a member of the AIVP network of port cities which provides signatory cities with good practices in various fields including territorial development policies and sustainable urban development. Being a part of this network allows the city to exchange knowledge and strengthen its sustainable urban development while adapting to climate change.

In an interview, a municipality of Rouen employee in charge of ecological transition (2019) explained that in the city, the sustainable development responsibility was attached to the general direction of the political service to ensure a transversal approach. He however clarified that climate adaptation, in particular, is not necessarily mainstreamed across various sectors. Many actors from different sectors at the heart of the municipality still work in silos, do not know their role in addressing the issue, or are not even aware of the importance of adapting the territory to climate changes (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

Various tools are set by the city of Rouen to boost citizens' participation in local politics. For instance, the city of Rouen has Neighborhood Councils which are spread throughout the territory. These district councils are relays between the inhabitants, the elected officials, and the services of the city and represent think tanks for improving the living environment of the inhabitants. The city has a participatory budget of around 1 million euros, dedicated to projects supported by neighborhood councils. These projects are studied in accordance with elected officials and are then submitted for validation to the Participatory Budget Council after conducting a consultation with the inhabitants and a feasibility study with the municipal technical services. These projects concern all the dimensions of the urban living environment such as green spaces, street furniture, waste management, and transportation. However, despite these efforts, the participation of citizens in the decision-making is very weak and limited (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

Upon the creation of 'Métropole Rouen Normandie' in 2014 and as some of the responsibilities and competencies of the municipality of Rouen got transferred to the Metropolis, officials at this level of governance became aware of the importance of addressing environmental and climate issues. A multidisciplinary and transversal project team, led by a Cit'ergie advisor, was set to develop the Metropolis of Rouen's Climate Air Energy Territorial Plan. In an interview with a Métropole Rouen Normandie employee at the directorate of environment and energy (2019), he asserted that "due to the complexity of these global issues, we became aware we cannot tackle

them on our own, and we need to work closely with various actors, therefore, we have decided to be the first territory to organize a local climate conference on the model of COP 21 in Paris”.

The project of COP21 Rouen Normandie was co-created with two partners, WWF and ADEME, to bring out concrete commitments of the actors of the territory. This initiative allowed to unite various actors to build their own engagement to the climate which took the form of a ‘Rouen Climate Accord’ (Métropole Rouen Normandie, ADEME & WWF, 2018) and was signed on the 29th of November 2018.

Various types of structures signed the accord such as municipalities, administrations, associations, coalitions, and enterprises, and consequently presented a list of climate engagements (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). The municipality of Rouen also engaged itself in the Rouen Climate Accord presented by the metropolis. However, an employee at the municipality of Rouen (2019) underlined that this climate accord was not much of added value to the city of Rouen itself as it was already engaged to take climate actions even before the local COP21 initiative proposed by the metropolitan area. He affirmed that “the city didn’t re-invent any engagement for the Rouen Climate Accord, it presented the ones it had for its air-climate plan and its agenda21”

The Métropole Rouen Normandie employee at the directorate of environment and energy (interview, 2019) clarified however that the local climate accord does not include a penalty system in case of non-compliance, it is a voluntary initiative and there is no system to monitor the engagements. Therefore, some administrations, communities or enterprises could sign the engagement only to give themselves a “green image”.

In alignment with the COP 21 initiative, the metropolitan area of Rouen Normandy decided to set up a local IPCC (GIEC local) bringing together scientific or local experts in various disciplines. This unprecedented unit on the scale of the metropolis made it possible to determine the role of each actor in ensuring a healthier and more resilient environment (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

The reports published by the metropolis of Rouen Normandy, including the territorial ‘air energy’ diagnostic, the PCAET, and the Rouen Climate Accord, underlined the share of various sectors in GHG emissions and in energy consumption as well as the role of businesses in the implementation of mitigation and adaptation measures. Moreover, the PCAET (Métropole Rouen Normandie & COP21, 2018) highlighted for each adaptation action to be undertaken between 2019 and 2024, the main stakeholders (including the leader of the action and the identified partners) that are responsible for implementing and following up on this action.

In recognition of the role of economic actors in climate action, the metropolis underlined in its territorial ‘air-energy’ diagnostic (Métropole Rouen Normandie, 2017) that it anticipates working in partnership with the Chamber of Commerce and Industry or the Consultative Council for Development and to establish a network of good practices allowing for an industrial ecological approach.

According to the climate accord (Métropole Rouen Normandie, ADEME & WWF, 2018), appointments have been proposed to energy-intensive companies and/or those with more than 100 employees in the context of the Cop21 initiative. An individual commitment from each of these companies has been recommended. However, it is important to mention that the focus of these

commitments is on mitigation rather than adaptation (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

The engagement of the private sector in numbers as presented in Rouen's climate accord
(Métropole Rouen Normandie, ADEME & WWF, 2018).

- Over one hundred companies met with.
- 71 individual engagements with companies and administrations with more than 30 000 employees.
- 18 business coalitions engaging nearly 1,000 businesses, merchants, craftsmen

Other tools were put in place by the metropolitan area to raise awareness about the issue of climate change and to incite the engagement of various actors in the ecological transition.

For instance, an online platform COP 21³⁰ was developed to reach a wide range of audiences, including the residents, associations, and enterprises. The website shed light on the metropolis' agenda and best practices and invited people to engage in the 'COP 21 locale'. The online platform is also meant to facilitate coordination and collaborations among various actors (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

Moreover, the Metropolis chose to develop a crowd-funding initiative (Je participe) to support local projects and engage citizens. The local climate accord (Métropole Rouen Normandie, ADEME & WWF 2018) expounded that the crowdfunding initiatives involve citizens in the choice of projects that can be supported by the community through a complementary grant, give legitimacy to project promoters, through popular support, and increases the chances of the success of planned actions as well as their acceptance by the citizens.

How does the 'crowd-funding' (Je participe) initiative work?

To propose a project, the concerned person can go to the platform dedicated to the call for projects and fill in a registration form. Once registered, a presentation form for the project is to be filled and submitted for validation. Experts in crowd funding accompany the actors to refine their funding strategy (launch date, duration, financing objectives, etc...) before the fundraising is launched. Only 70% of the financing of the project is through crowd funding, the rest will be automatically paid by the Metropolitan area of Rouen Normandie if the collection of funding proved to be successful (in the limit of 4 000 € per project) (Métropole Rouen Normandie, ADEME & WWF, 2018).

The metropolis Rouen-Normandie has also initiated the label "COP21, je m'engage pour le climat" which translates to 'I commit myself for the climate'. This label is open to all event organizers to reduce the pressure on the environment. This action allows them to adopt eco-responsible actions for the management of their event (ex. Use of eco-cups, reduction, and sorting of waste etc.).

The interviews conducted with local actors have shown that environmentalists at the municipality of Rouen, at the Métropole Rouen Normandie and at the regional environment agency, are aware that the mobilization of local actors (citizens, companies, associations, etc.) is vital to incite the development of practices and technologies that will help achieve environmental and climate goals.

³⁰ www.notrecop21.fr.

Key stakeholders are conscious that the mobilization requires communicating information as well as the adherence and the commitment of all the actors to taking climate action. Environmentalists at both scales of governance highlight that there is a room for improvement and are trying to drive this change. Both interviewed employee at the municipality of Rouen (2019) and the regional environmental agency of Normandy (interview, 2019) stated that some efforts have been deployed to assure a transversal approach and integrate a participatory culture, however communities and structures within the community still work in silos. Interviews with key actors underlined that there is no real coordination between decisions and actions taken at the scale the city of Rouen and the metropolitan of Rouen area level and across various sectors.

Despite efforts to engage citizens, participatory policies are still at the embryotic stage. “Not many people are informed and aware of existing projects and initiatives ensuring their participation in the decision-making process” asserted a climate researcher at the University of Rouen (interview, 2019). He expounded that “citizens are rather at the other side of the conversation, they are not really involved in the decision making, and communication with them about environmental matters is limited to raising awareness and informing them about the efforts undertaken at the city or the metropolitan scale”.

4.1.4 Implementing Developed Strategies: Small-scale adaptation initiatives and projects to increase the attractiveness of the city, contradictions between the set vision and implemented projects

In France, following the heatwave of August 2003, and as of 2004, each city of more than 5000 inhabitants was required to establish a list of old people susceptible to hot temperatures as part of its ‘Plan Canicule’ (Or heatwave plan). The SGAR technical report (2013) underlined that this initiative has proved to be efficient as its implementation during the heatwave of summer 2006 helped reduce excess mortality. However, the solidarity plan is focused particularly on the elderly, does not include all vulnerable people (people with illnesses and/or young children) and it only applies to people with no family or with no support. Not to mention, the registration of people for the Seniors Solidarity Alert Plan is voluntary and optional. An employee at the municipality of Rouen in charge of ecological transition (interview, 2019) highlighted that there is still room for improvement, particularly in developing strategies or measures related to adapting to heat waves and reducing the UHI effect.

Through various communications, the city of Rouen highlighted the actions that have been undertaken to adapt the city to climate change. Moreover, the city’s Agenda 21 and PCET present implemented actions as well as actions to be completed by a set deadline. The implemented actions include gradually introducing sustainable development criteria and allocating subsidies to associations to accompany them in their evolution towards sustainable practices. The city also ensured the integration of environmental issues in the local magazine and the dedication of sections and articles to this topic to establish a shared culture of sustainable development. In addition, the municipality is working on considering the risks linked to climate change adaptation in urban planning operations and documents. Rouen’s PCET (2013) specifies that the city has also developed a set of concrete and measurable indicators enabling the assessment of policies in relation to key environmental challenges.

To address the issue of heatwaves and reduce the UHI effect, the city of Rouen is working on preserving and protecting natural environments and increasing the share of greenery. In an article published by the city of Rouen (2019) in its local magazine, the previous mayor of the city, Yvon Robert, serving between 1995 until 2001 and re-elected in 2012 to serve until 2020, avowed that for several years Rouen has been particularly sensitive to questions relating to nature and the environment in the broad sense. According to the article (City of Rouen, 2019), the mayor believes that green spaces are not only intended to increase biodiversity in cities but also allows for limiting the UHI effect while providing places for meeting and increasing the feeling of belonging to a community. Moreover, the article presents the city's objective to renovate parks and squares and increase the share of greeneries. Concretely, this translates into imposing a minimum of 10 to 20% of vegetation space for any new construction or project (City of Rouen, 2019). Additionally, four pocket parks are to be developed in 2019 and 2020 replacing parking spaces (City of Rouen, 2019).

Examples of projects that are already completed or in progress include the Eco Valley of the two rivers (Éco-vallée des deux rivières) and the shared garden of the Lombardy (Jardin partagé de la Lombardie). The first project aims on enhancing the attractiveness of the ecological, historical and landscape heritage of the natural sites of Repainville, Côte Sainte-Catherine, and Saint-Exupéry. The second offers a 700 m² plot allowing for children and adults to learn more about urban agriculture. Nonetheless, an employee at the regional environmental agency of Normandy (interview, 2019) affirmed that the greening of the city is mainly done to make the city more attractive rather than with a primary goal of adapting to climate change. He explained that “the elected officials like such projects as they are well perceived by citizens and increases their chances of being re-elected”. Research has shown that cities are more likely to adopt adaptation or mitigation actions when local actors see immediate value for themselves and when there are co-benefits (Baggioni & Bouisset, 2018; de Sartre *et al.* 2021).



Figure 15 Left bank quay of the Seine in Rouen. Photo taken in June 2019.

City officials stated that climate actions don't necessarily consist of new or specific measures. Some actions are implemented with another primary goal in mind; however, it improves the adaptability of the territory (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019). For example, the rehabilitation of the Seine quay in Rouen was initiated by the mayor, Yvon Robert during his first term (1995-2001), to create an eight kilometers long public park along the seine river with spaces dedicated to leisure as well and spaces serving the economic activity. While this project (*figure 15*), which was implemented in phases throughout 30 years, provides a green promenade for the local citizens along the river, it also acts as a buffer zone in the events of river floods (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019). The project, initially conceived with the ambition of increasing the attractiveness of the city, now provides an opportunity to connect citizens with nature and increases urban resilience (Regional environmental agency of Normandy employee, interview, 2019).

To address the issue of reduced water availability the city of Rouen (n.d.) communicated on its official website that it is streamlining water use and consumption through monitoring the water consumption of its buildings, assuring the maintenance of pipes to prevent leaks, and installing small water-saving equipment (tap aerators, sensors, etc.) as well as rainwater collectors. Moreover, it is ensuring better management of green spaces through planting vegetation requiring less watering. The city is also working to reduce the amount of drinking water used for the cleaning of pavements and sidewalks (City of Rouen, n.d.).

The implementation of certain adaptation measures in Rouen proved to be remarkable and award worthy. As a case in point, the city of Rouen was awarded first prize in the category "Facilities, infrastructures, and buildings" during the Climate Adaptation & Territories 2014 Awards. The project of the eco-district ZAC Luciline-Rives de Seine, which covers an area of 9 hectares, has attracted the attention of the jury of the ADEME. The project stood out for the measures taken in terms of the adaptation actions which included the protection against flood risks, the reduction of heat island effects, the development of urban biodiversity, and the reliance on renewable energy (Moiroud-Musillo, 2014). Geothermal energy is used to satisfy 60% of the heating needs of the neighborhood using underground water (of a constant temperature of approximately 14°C). This heating network serves for cooling offices and commercial centers during summer (Moiroud-Musillo, 2014).

The eco-district of Luciline (*figure 16*) is part of a program entitled "Future Cities-urban networks to face climate change" which groups European experiences of adaptation to climate change (Jardot, 2015). The design of this project has been the subject of an environmental approach to urban planning to regain an industrial site and make it a new urban centrality. The pursued objective is the creation of a neighborhood adapted to climate change with a low environmental impact. An important place is dedicated to nature in this project with the garden 'Mail André Putman' as well as trees on the side of the road. The landscape has a twofold objective: provide spaces dedicated to pedestrians and enrich the area's biodiversity (Jardot, 2015). The increase in heavy rain events was considered in the design of this neighborhood. Consequently, various green areas, several channels, as well as water retention basins were developed in the district. According to a 'twinning report' produced by the European Commission & Covenant of mayors (2016), in this

project 20% of the ground serves to infiltrate water to the ground, the infiltrated water goes into the rain garden of Mail André Putman, then flow for to be thrown in the Seine River. Moreover, the ground floors of the buildings are raised to ensure they wouldn't be flooded. The report specified that "unlike many neighborhoods located along the Seine, Luciline was not flooded during the severe overflow in June 2016". Nonetheless, the field visit revealed that the eco-neighborhood represents an experimental punctual initiative, as it only covers 0.42% of the total area of the city (9 out of 2138 hectares), while other constructions in the city are built with no regard to climate change adaptation.



Figure 16 Ecoquartier Luciline. Photo taken in June 2019.

An employee at the regional environmental agency (interview, 2019) affirmed that, as the eco-district of Luciline proved to be successful, the initiative is being replicated and scaled up to cover a brownfield of 90 hectares in the neighborhood of Flaubert on the South Bank of the Seine River. The development of the presqu'île rollet park, an urban park stretching for several kilometers along the left bank of the Seine, plays an important role in the support of biodiversity. This project is part of a wider project that is to change the Flaubert neighborhood into an eco-neighborhood.

In Rouen, the implementation of projects is still at its early stages as many projects are still in progress. Employees at the municipality of Rouen and the Métropole Rouen Normandie underlined in the conducted interviews that implementing adaptation actions can't be done overnight. "Lengthy processes are required, and the results can't be directly observed", specified an employee at the Municipality of Rouen in charge of ecological transition (interview, 2019) explaining, "to increase the share of greenery, new vegetation needs to be planted, and it could take at least 10 years for a tree to grow". Moreover, an employee at the regional environmental

agency (interview, 2019) highlighted that there are a lot of contradictions when it comes to the implementation and the development of new projects and stated that “many public projects are not aligned with the intention of ensuring a sustainable development at the scale of the territory”. An employee at the municipality of Rouen at the directorate of attractiveness and living environment (interview, 2019) affirmed the previous statement and elaborated that the city is aiming at increasing the share of greenery and improving the permeability of its surfaces to reduce the risks of flooding yet “some new projects at the urban scale are quite mineralized, do not increase planted areas such as the renovated forecourt of the Rouen station [figure 17] which was inaugurated in May 2019” (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019).



Figure 17 Mineralized forecourt of the Rouen station inaugurated which was inaugurated in May 2019. Photo taken in June 2019.

The SRCAE (ADEME et al., 2013) have underlined that one of the barriers to the implementation of adaptation and climate action plans is the need for financing projects and measures. It elaborated that, large investments are needed for the rehabilitation of buildings and infrastructure to increase their adaptability and resilience to climate change. “This is why urban rehabilitation projects are often spread over a large period of time to ensure financial feasibility, just like the development of the Luciline eco-district which was spread over 10 years” expressed an employee at the municipality of Rouen (interview, 2019).

The SRCAE (ADEME et al., 2013) also indicated that it is necessary to develop modalities of innovative financing to maximize the implementation of various environmental initiatives and asserted that the mobilization of public funding and financial tools linking public-private efforts is indispensable to address environmental and climate concerns.

Several European, national, and regional funding schemes already exist. For example, the 'Atopica program' is funded by the European Union and co-led by research organisms and aims to better understand the respective effects of climate, land use, and air quality on allergies related to pollen. However, according to the SRCAE (ADEME et al., 2013), there's a need for easier access to these aids, the development of one-stop shops, and the homogenization of their criteria.

Provisional costs for the implementation of adaptation actions and the share of grants covering these costs are highlighted in the PCAET. Nonetheless, the share of grants covering provisional costs remains trivial. The metropolis of Rouen Normandy is seizing to develop new financing opportunities by developing partnerships with various stakeholders such as local actors, the region Normandy and the ADEME. Additionally, the metropolitan area developed a crowd-funding initiative (*Je participe*) to ensure the financing of environmental measures and projects (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

On its online platform, the Regional Environment Agency Normandy (2018) published a press release in which it stated that the Rouen Normandy Métropole was awarded the "Best Intercommunality for Biodiversity" prize for 2018. The metropolis owed this distinction to exemplary actions in the preservation, management, and restoration of biodiversity, which concern a wide variety of environments.

In interviews with city officials, scientific experts, and representatives of the metropolitan area in Rouen, they all agreed that financial, human, and technical resources are major barriers to the implementation of adaptation strategies. They expressed that the limited financial resources confine the ability to hire experts and suitable human resources, elaborating that it also restricts the access to adequate equipment or tools which facilitates putting into practice developed adaptation strategies.

Key stakeholders also highlighted that it is hard to define the share of the budget related to sustainable development or adaptation strategies because sometimes it is hard to categorize actions. For instance, "developing the public transportation system is considered part of the budget related to transportation but is also important to reduce GHG emissions" explained a Métropole Rouen Normandie employee at the directorate of environment and energy (interview, 2019).

4.1.5 Monitoring and Evaluation: *Cit'ergie*, a label used as a tool to assess the progress of environmental action

After adopting its sustainable development and energy-climate policy, the City of Rouen desired to be part of a continuous improvement process and give a new dimension to its engagement. It

has therefore voluntarily committed itself to a 'Cit'ergie³¹ labeling approach since 2013 (Municipality of Rouen employee in charge of ecological transition, interview, 2019). This label is used to help local governments monitor and assess the implementation of their strategy to ecological transition through a series of qualitative and quantitative indicators. It allows to have an evaluation system that is common to all territorial collectivities in France, making it possible to compare their efforts, deduce success factors and create a network of exchange of best practices. In an interview, the Rouen Cit'ergie consultant (2019) asserted that the label allowed both the city and the metropolitan area to strengthen their internal dynamics and build a climate action program.

The Cit'ergie label evaluates the action of cities and communities in the context of climate action and ecological transition. Every year, the committed city or community receives an annual visit from its Cit'ergie advisor who follows the progress of the implementation of its climate-air-energy action program. And every four years, the label awarded to a community is reconsidered based on a re-assessment (Rouen Cit'ergie consultant, interview, 2019). However, this tool is not solely concentrated on the assessment of adaptation actions but also includes the evaluation of implemented mitigation measures.

Based on the benchmark, Cit'ergie evaluates the potential of actions of communities in France according to their skills, and awards a label based on three levels of performance. A 'Cit'ergie Gold' label is awarded when the percentage of implemented action exceeds 75% of the maximum potential, a 'Cit'ergie' label is awarded when that percentage is greater than 50% and 'cap Cit'ergie' label is awarded when the percentage surpasses 35% of their maximum potentials.

According to the Cit'ergie assessment, the city of Rouen has implemented around 54% of its maximum potential and obtained the "Cit'ergie" label in 2018.

The Cit'ergie labeling system sheds light on actions undertaken by the city of Rouen, in all six areas defined by the label and underlines the importance of redefining urban spaces and limiting urban sprawl. Given that the city of Rouen engaged in the labeling process since 2013, the evolution in the implementation of environmental and sustainable development measures can be defined as seen in the diagram below (*figure 18*). Results show that the city's total Cit'ergie score has increased from 41.8% to 54.3% between 2013 and 2018 which proves that it is actively working and implementing actions to reach its objectives and ensure a sustainable urban development. Moreover, the results demonstrate that the city's score has improved in all areas and predominantly in the area of 'communication and cooperation'. Rouen scored the highest in the area of 'internal organization of the community' in comparison to other axes of action. Nevertheless, it still has a weak performance in the area of 'energy supply, water, sanitation and waste management'. The city of Rouen has not yet reached its defined objectives in various areas of action, which underlines the need for a continuous improvement.

³¹ Cit'ergie is a label that rewards and supports local authorities in the development and implementation of their PCAET (Métropole Rouen Normandie, 2017).

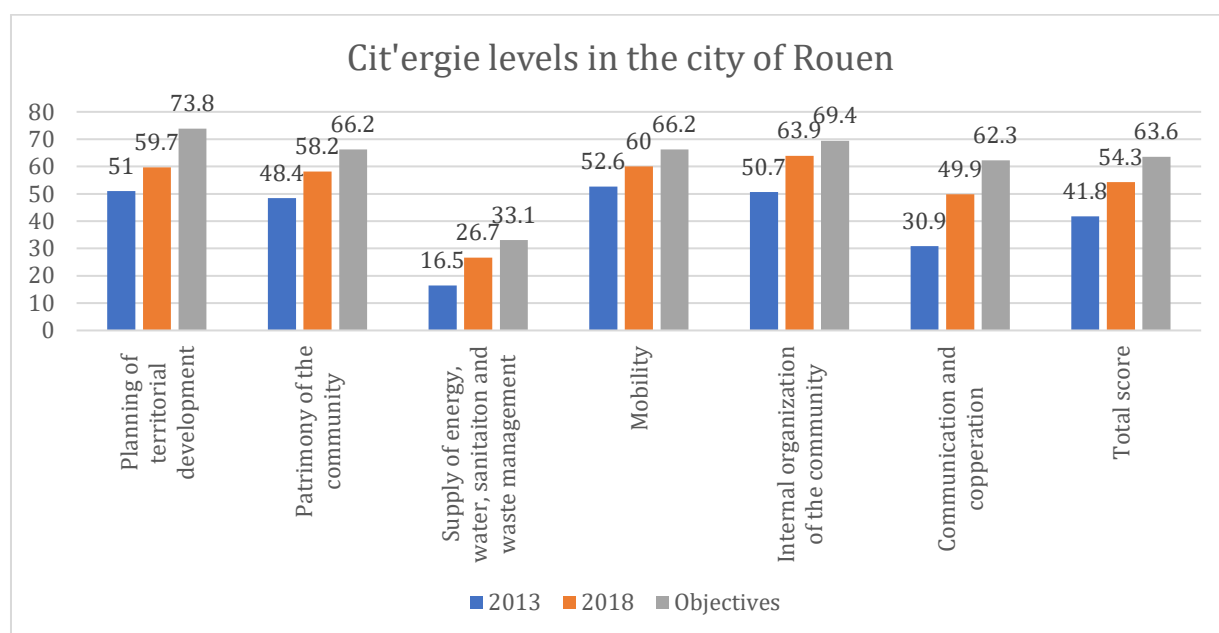


Figure 18 Cit'ergie levels in the city of rouen in 2013 and 2018. Source: Values presented in the graph above are retrieved from Cit'ergie's official website <https://citergie.ademe.fr>.

In addition to the Cit'ergie tool, the city's agenda 21 describing the different aspects of its public policy, is accompanied by an external cabinet which makes an objective evaluation, indicates the points of strengths as well as the points of weaknesses, and integrates the political objective to define global objectives.

The indicators highlighted in the city's first action plan included: Number of days in which the index of good quality air is not reached (Atmo index), an ecological diagnosis of the city, the summary of the application of the local plan of urbanism in terms of housing and an investigation of how the citizens perceive their city.

In the second action plan of the city's agenda 21, the indicators were more elaborate. Almost each one of the 29 actions to be carried as highlighted in the action plan had at least one monitoring indicator. These indicators included, the percentage of energy-saving and energy expenditure, the number of commissioned projects for urban gardening or other forms of vegetation as well as the number of conducted workshops, and the number of actions carried out to raise awareness. Moreover, the city monitors indicators of attendance, the number of people trained, the number of pupils and scholars who took part in the action, and the number of institutions wishing to benefit from the awareness-raising campaigns. To assure this monitoring, the city collects data from different city departments and relies on information and statistics developed by various regional and national institutes such as the INSEE, ATMO, and ADEME (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019).

After the formation of the metropolis in 2014, the Métropole Rouen Normandie decided in 2016 to engage in the Cit'ergie labeling process. This engagement allowed the metropolitan to be accompanied in the construction of its PCAET and to receive the "Cit'ergie" label in 2018 (Rouen Cit'ergie consultant, interview, 2019).

Through this process, the intention of the Metropolis was twofold: First, to engage in a process of continuous improvement carried out as part of a project shared by all the actors of the territory and services of the community. Second, to have national and European recognition of the quality

of its energy efficiency policy and climate actions at the level of its territory (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

The Cit'ergie evaluation is presented on an online platform³² and considers the implemented measures through monitoring indicators, as well as actions in progress or planned by the metropolis. Given that the engagement of the metropolis in the labeling process is relatively recent, the progression in the implementation of actions is not yet defined. However, the Cit'ergie level depicting the implementation of actions for the year 2018 is presented as follows as retrieved from the initiative's official website:

66.5% in the area of 'planning of territorial development'

45.2% in the area of 'patrimony of the community'

45.7% in the area of 'energy supply, water, sanitation and waste management'

53.4% in the area of 'mobility'

49.8% in the area of 'internal organization of the community'

61.9% in the area of 'communication and cooperation'

54.2% in total

The Métropole Rouen Normandie underlined in its Rouen Climate Accord (2018) that regular assessments will be based on the monitoring of strategic objectives at a local level with the support of regional authorities. Annual reports will be realized to evaluate the actions of various actors of the territory and the Metropolis. An independent body of experts from the civil society and private sphere will be created to follow this assessment: the "Evaluation Council of the Rouen Agreement³³". The council will be assembled every year to evaluate the progress of the ecological transition as well as the mobilization of actors (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

In addition to the qualitative and quantitative indicators fixed by the Cit'ergie process, the metropolitan of Rouen Normandy has fixed its proper indicators to evaluate the progress in the implementation of its climate actions. Consequently, each of the 40 actions highlighted in the metropolis' climate action plan has at least 1 monitoring indicator. For instance, for the action aiming at promoting sustainable urbanism, the metropolis has fixed 3 indicators: the cumulative surfaces of new areas open to urbanization, the evolution of space consumption related to urbanization (hectare / year); and the number of supports provided by project leaders on the aspect of nature in the city.

To evaluate the improvement of knowledge related to climate change, the metropolis examines the number of publications conducted by the local IPCC, the number of studies conducted on the role of carbon storage in agricultural, forest and natural environments as well as the number of participants in awareness-raising actions. Moreover, the metropolis inspects the evaluation of the quality of underground water as well as the number of engaged and implemented actions to prevent inundation. To assess the citizens' participation the metropolis examines the number of people registered on the social networks and the citizen platform, the participation rate at meetings / organized events as well as the number of projects supported, and the amount of aid provided.

³² <https://citergie.ademe.fr>.

³³ Le conseil d'évaluation de l'Accord de Rouen.

4.1.6 Understanding Success and Limiting Factors: The willingness to go beyond legal requirements challenged by the lack of resources

In the city of Rouen, studies have been conducted to elaborate the second action plan of the agenda 21 based on the first version of the agenda 21 and the annual reports of Sustainable Development. These studies made it possible to identify the weaknesses to be surpassed, the strengths, and the assets on which local authorities could develop the new action plan.

The challenges particularly faced at the scale of the city of Rouen were presented by Lesconnec (2017) in a sustainable development report to the municipal council. These challenges include the need for complementarity between the policies implemented by the City and the Metropolitan Rouen Normandy in terms of energy and climate, as well as the need structuring and strengthening of the social component. Lesconnec (2017) also underlined other challenges including efforts required to ensure the involvement of stakeholders and civil society as well as their acculturation, the management of the internal change of services, and the need to ensure a simple assessment of the impact of policies and actions. Lastly, Lesconnec (2017) stressed the importance of reporting back to citizens on the progress of the agenda 21 through annual sustainable development reports.

The metropolis, in its 'climate accord' publication (Métropole Rouen Normandie, ADEME & WWF 2018), presented the complexities and challenges faced at a local scale in ensuring an ecological transition and implementing the developed strategies as follows:

First, it asserted that the renovation of tertiary buildings to adapt to climate change and limit energy consumption seems a complex task due to certain constraints such as additional costs, nuisance, low and slow return on investment, and the lack of aid schemes. Not to mention, not all occupants own the premises or are motivated to make renovations.

Second, the metropolis, raised in its climate accord, the challenges faced in increasing urban agriculture and preserving natural resources (water and biodiversity). These challenges include high costs, the low availability of farmland, the strong orientation of local agriculture towards export (linked to the presence of port) rather than being focused on the local production of food. Third, Rouen's climate accord stressed the complexities of mobilizing actors to participate in the preservation of biodiversity and the adaptation to climate change. (Métropole Rouen Normandie, ADEME & WWF, 2018).

The Cit'ergie diagnosis made it possible to evaluate the actions implemented by the city and the Metropolis of Rouen and to identify areas of progress by field of activity as well as areas that require more attention (Rouen Cit'ergie consultant, interview, 2019).

For instance, in the area of Territorial development and planning, the Metropolitan's climate commitments seem ambitious and are presented in several documents (PCAET, Master Plan of Energies and the Local inter-communal urban plan) affirmed the Rouen Cit'ergie consultant (interview, 2019), stressing however that "more attention must be paid to the translation of these documents into objectives and operational action programs". He elucidated that one way for the progress in the area of 'communication and cooperation' would be to put in place a communication plan around the "climate air energy" policy to strengthen the mobilization of all the actors of the territory, and to consolidate various stakeholders in the development and implementation of various initiatives.

An environmental assessment report of the PCAET for the period 2019-2014 was conducted by Ernest & Young (2019), a global consulting firm, on behalf of the Métropole de Rouen Normandie. The evaluation process resulted in the identification of the probable effects of the implementation of the PCAET on the environment and the characterization of these impacts based on their aspect (e.g., negative/positive impact; direct/indirect impact; temporary/permanent impact) as well as their time horizon. The report identified the measures promoting positive impacts and what should be done to avoid, reduce or compensate for negative impacts.

The environmental assessment report of the PCAET underlined that the measures presented in the climate plan could have potential pressure on land-use, resources, and natural environments in the medium term. The report therefore specified that landscape considerations should be integrated into decision-making and consultation processes. It also asserted that the PCAET includes a limited number of measures developed to take better account of the management of water resources. According to the developed report, impacts on natural and technological risks should be carefully monitored. Also, potential significant local impacts on the development of nuisance must be anticipated during the consultation strategies at the beginning of projects.

While meeting with various key local actors, they highlighted that assuring the continuity of environmentally responsible actions, the respect of engagements and the concretization of intentions is a great challenge. An employee at the regional environmental agency (interview, 2019) underlined that adaptation is a long-term process that requires taking actions while considering impacts at far horizons such as 2050 and 2100, while the political mandate is of 6 years. "Short-termism and wanting immediate results could impact the long-term resilience of the territory" (Regional environmental agency of Normandy employee, interview, 2019). Officials at the scale of the city and the metropolis highlighted that it is very complicated to find the right balance between being pragmatic and being ambitious (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). Moreover, various actors at the scale of the city and the metropolis stated that prioritizing actions and creating synergies across sectors and different levels of governance is a complex task. All key actors agreed that the lack of financial, human, and technical resources remains the principal barrier to the development and the implementation of corresponding adaptation strategies (Municipality of Rouen employee in charge of ecological transition, interview, 2019). It is also important to underline, the particularities of the geographical context of the city of Rouen make things more challenging as the city is in the center of a topographic depression (Climate researcher at the University of Rouen, interview, 2019). A municipality of Rouen employee in charge of ecological transition (interview, 2019) affirmed that one of the most challenging tasks is the integration of rainwater management in urban projects as well as the development of blue infrastructure systems reducing the risk of inundation and refreshing the city. Nonetheless, preventive flood risk actions have been undertaken by the metropolis since 2005, promoting rainwater management and integrating risk into new urban development projects or agricultural practices (Métropole Rouen Normandie, 2017).

In an interview, a Métropole Rouen Normandie employee at the directorate of environment and energy (2019) stated that the local COP21 initiative presents a great opportunity and is a lever to the governance of climate change adaptation at the scale of the territory as it was able to engage various municipalities, enterprises, and organizations to address climate issues. He also highlighted

that some institutions (e.g., ADEME) and NGOs (e.g., WWF) played a huge role in supporting the initiative. Not to mention, the establishment of the local IPCC to improve knowledge and the understanding of the impacts of climate change at the scale of the territory is perceived as a principal driver to adaptation (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). A regional environmental agency of Normandy employee (2019) stated in an interview that the willingness of both the city and the metropolis to go beyond the legal requirements has been a great leverage to increasing the adaptability of the territory. Lastly, local actors believe that the fact that the city is starting to sense the impacts, as changes are becoming a reality and are no longer projections, has been a real driver to acting on the matter (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019).

4.1.7 Improving the Governance System in Place: Cultivating knowledge, developing climate plans in respect to new laws and constitutional changes

“Given that the strategy developed as well as the initiatives implemented at both the scale of the city and the metropolis are relatively recent, one can’t say whether they have increased the city’s resilience or not” stated a Regional environmental agency of Normandy employee (interview, 2019). This was confirmed by a municipality of Rouen employee in charge of ecological transition (interview, 2019) who expressed that “the implementation of actions is progressive, and results could take a long time to manifest”.

It is however important to highlight that increased attention is being given to climate change adaptation by both the city and the metropolis of Rouen as the impacts are already being felt at the scale of the territory. Yet, mitigation measures are still more elaborate and adaptation policies need to take into consideration that these impacts will increase in frequency and intensity (Climate researcher at the University of Rouen, interview, 2019).

Some research projects are already in place to develop a further understanding of the impacts of climate change and to develop new ways of addressing them. As a case in point, the local IPCC is working on producing new scientific contributions at the scale of the metropolis, especially on the theme of the impact of change climate change on the urban environment, water resources, biodiversity, and public health. Yet a climate researcher at the University of Rouen (interview, 2019) emphasized the need to fund and develop research on the topic of climate adaptation.

In an interview, a Métropole Rouen Normandie employee at the directorate of environment and energy (2019) affirmed that the structure he represents is aware that it needs to adopt a strategy of anticipation of risks and adaptation in the light of the intensification and increased frequency of impacts of climate change. It is also conscious that the development of such a strategy requires in the first-place consolidation of prospective scenarios across the territory allowing to apprehend risks in the medium and long term (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019).

According to the metropolis’ climate accord (Métropole Rouen Normandie, ADEME & WWF, 2018), the first steps of the ‘climate-air-energy’ policy must therefore make it possible to understand and study the vulnerabilities, and to anticipate them by adopting the necessary policies and actions.

In the case of both the city and the metropolis of Rouen, the development or the update of the adaptation policies isn't primarily done based on recent impact assessments. Both the city and the metropolis are relying on the results of the regional analysis conducted by the SGAR in 2013. The update of adaptation policies in the case of the city and the metropolis was assured following the development of new laws as well as constitutional changes. On one hand, the PCET was developed in response to Grenelle II law and served as a 'continuity' of the city of Rouen's agenda 21. On the other hand, the PCAET was developed 5 years later after the formation of the metropolis and in response to the law relating to the energy transition for green growth. Nonetheless, it is important to underline that the city of Rouen developed its first action plan of the agenda 21 without any legal obligation and updated its action plan based on the results of the analysis of the first action plan (2011-14) which identified new challenges to be addressed in the second action plan (2017-2021).

The PCET enriched the action of the local agenda 21 to address the issues of energy and climate (City of Rouen, 2013). New actions included:

- Adding a "sustainable development monitoring" in the validations circuit of the municipal deliberations.
- Making it mandatory for all directorates to present sustainable development projects and actions planned or achieved in the budget preparation notes and reports activity.
- Identifying Energy and Climate issues.
- Signing the Covenant of Mayors "For Sustainable Local Energy".
- Carrying out a communication plan specific to sustainable development to incite partners and locals to use the soft modes of movement.
- Strengthening the consideration of energy and climate in urban planning documents and continue the fight against urban sprawl by increasing the density of the city center and of the areas connected by public transportation.
- Considering the risks associated with climate change adaptation in operations of urbanism.
- Integrating energy-climate issues into agents' training, assessment, and job descriptions (City of Rouen, 2013).

An updated action plan of the city of Rouen's agenda 21 was established focusing on reinstating the city's commitment and setting new and updated pragmatic actions corresponding to its new competencies, given that the formation of the metropolis affected the municipality's responsibilities. For example, as of the first of January 2015, the competency of developing a local urban plan was transferred to the metropolis of Rouen. This plan needs to be compatible with the PCAET and thus needs to be considerate of the environment and natural resources.

The PCAET, developed after the formation of the metropolis, proceeded the PCET, but can't be compared to it as it is done at a different scale. The law that allowed for the formation of the metropolitan Rouen Normandy ensured the development and expansion of adaptation projects on a larger scale, including the suburbs of the city and nearby towns. A climate researcher at the University of Rouen (interview, 2019) highlighted that it is essential to take climate actions at the scale of the metropolis rather than the scale of the city as it allows for the pooling of resources. However, a municipality of Rouen employee in charge of ecological transition (interview, 2019) stated that this act also reduced the focus on the city of Rouen when it comes to impact assessments, the development of specific adaptation strategies and their implementation. "The

formation of the metropolitan reduced the city's ability to take actions, hindering it from moving forward in certain fields of action as it now depends on the rhythm of the metropolis" expressed a Municipality of Rouen employee at the directorate of attractiveness and living environment (interview, 2019). The lack of synergies and coordination between both levels of governance, mostly associated to the fact that both scales of governments have opposing political views, has aggravated the situation (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019).

The PCET developed by the city of Rouen (2013) stated that it is necessary to consider the risks associated with adapting to climate change in operations and planning documents to protect the city and increase its resilience in the face of flooding and heavy storms. The municipal plan has incorporated the requirements of the flood risk prevention plan (PPRI) emanating from the DREAL regulatory document which defines the constructability rules in areas that are likely to be flooded. (City of Rouen, 2013).

Rouen's PCET (City of Rouen, 2013) specified that a Municipal Protection Plan (PCS³⁴) has been adopted to increase the city's resilience and its preparedness to various events of emergency including natural risks (e.g., seism or flooding), health risks (e.g., heatwaves or allergic reactions), technological risks (e.g., nuclear risk) and extreme weather events (e.g., heavy storms). The objective of the PCS is to prepare the commune through formations, organizational methods, and technical tools to deal with emergencies and manage unavoidable crises. As part of its PCS, the city of Rouen drew up a communal information document on major risks³⁵ which aims to inform about the natural and technological risks to which the territory is exposed. However, it is important to underline that the PCS was instated by a law in 2004 for civil security purposes and was not conceived with climate adaptation in mind, but rather as a document to assure preparedness and crisis management.

In March 2021, the metropole Rouen Normandie launched an SMS alert system to warn the population in the event of an industrial accident, attack or environmental or meteorological disasters such as heavy storms floods, or heatwaves. This comes after the warning systems in place proved to be inadequate following the industrial fire incident of September 2019. The newly developed alert system informs the population of the nature of the event and the instructions to be applied (AFP, 2021).

4.1.8 Assessing the Urban Climate Adaptation Governance of Rouen

The collected data for the case of Rouen presented in the sections above (*sections 4.1.1 – 4.1.7*), through the review of various documents and the conduction of interviews with various key actors, allowed to answer the set of 50 close-ended questions that were presented in the methodology (*section 3.6.1*) forming the urban climate adaptation governance index.

The application of the developed index to the city of Rouen has showed that the assessed city has a moderate adaptation governance approach with a quantified value of 5.8/10 (*refer to appendix III– table 12* that provides detailed responses to the 50 questions of the index). This means that the city is aware of the importance of addressing climate impacts and is developing adaptation

³⁴ (Plan communal de sauvegarde), The ministry of interior highlights that the PCS is made mandatory as of 2004 to municipalities with a plan for preventing foreseeable natural risks.

³⁵ DICRIM or Document d'Information Communal sur les Risques Majeurs.

policies and strategies in response, however, lacks the appropriate resources to implement the proposed measures.

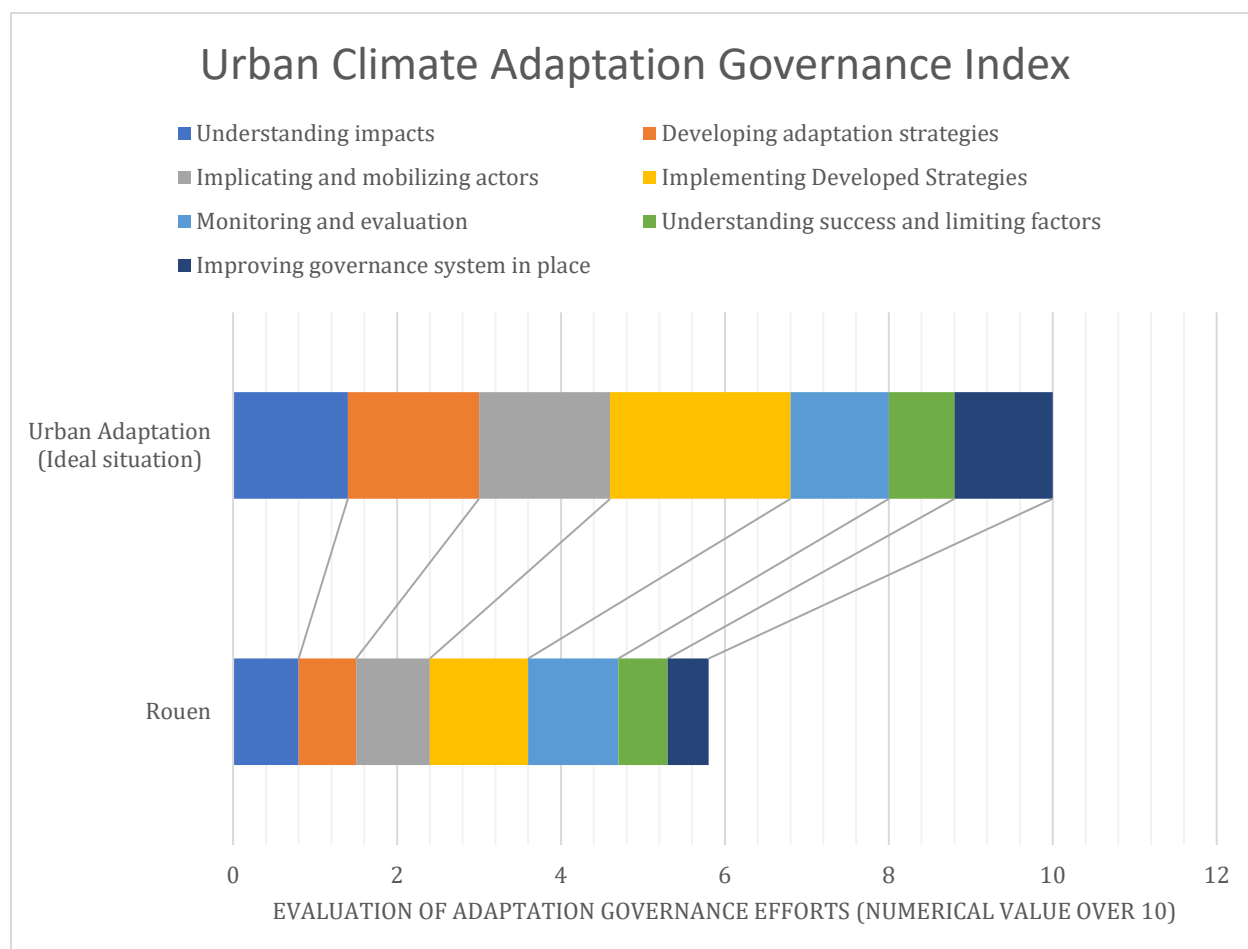


Figure 19 Visualization of the index score of the City of Rouen across various areas of climate adaptation governance.

The visualization of the results displayed in the figure above (*figure 19*) presents a detailing of the city's index score in the various areas of climate governance introduced in the conceptual model (*section 3.4*).

The results (*detailed in appendix III– table 12*) show that the city has a medium understanding of the impacts of climate change at a local scale affecting its adaptive capacity to climate events. The development of in-depth knowledge on the vulnerability of the city, the different sectors, and the residents to various climate events (Floods, heatwaves, lack of water availability, etc.) could thus improve the government's response to climate events. The city could also develop a mapping of vulnerable areas to define the areas of intervention. The index score also shows that the city needs to improve its performance in the area of developing adaptation strategies. In this context it is important to underline that Rouen does not have a proper adaptation strategy, instead, it has a climate-air-energy strategy that encompasses some measures permitting to increase the city's adaptability to climate events. This underlines the importance of developing proper adaptation strategy tailored to the assessed impacts. The visualization of the index score (*figure 19*) shows that the city is working on implicating and mobilizing actors and implementing projects to increase its adaptive capacity and boost its urban climate resilience. However, more efforts and the

dedication of appropriate resources are necessary. Rouen's remarkable performance in the area of monitoring and evaluation is contributing to improving the city's adaptation governance approach. This is explained by the city's commitment to the Cit'ergie label allowing it to assess its activity in the area of sustainable development and environmental and energy management. Key local actors are well aware of the success and limiting factors to the governance of climate adaptation at a local scale, however, more efforts are needed to allow for improving the governance system in place and increase urban climate resilience.

4.2 The case of Nijmegen, the Netherlands



Figure 20 The city of Nijmegen. Source: Google Maps, 2021.

Nijmegen is analyzed to develop a better understanding of climate governance in a mid-sized city in the Netherlands, a country that has embraced climate-proof spatial planning. To assure data collection, published literature was reviewed including documents and articles developed by various environmental agencies, adaptation platforms, and academic researchers. Environmental and climate policies, as well as territorial plans developed by the province of Gelderland and the municipality of Nijmegen, were also examined. Lastly, articles and documents published by the local press and the city's official website were reviewed.

For this case, and due to Coronavirus travel restrictions imposed in 2020, a field visit was not possible. Online interviews were conducted with different actors including a climate adaptation strategist at the province of Gelderland (2020); an adaptation policy advisor at the municipality of Nijmegen (2020), an environmental researcher at the Radboud University (2020). An interview was also conducted with a climate consultant working at a company providing its services to promote climate policies and ensure sustainable development who will be referred to as 'Nijmegen Climate consultant' (2021). These interviews allowed to develop an improved understanding of the current situation in the domain of climate adaptation in the city of Nijmegen.

The data collected, both primary and secondary, are presented below and organized following the 7 areas of focus in the governance of climate adaptation which were defined in the developed conceptual model (Section 3.4).

Nijmegen, situated in the province of Gelderland, is considered the oldest city in the Netherlands. It is part of an intermunicipal formation founded in 1988 known as the 'Arnhem-Nijmegen metropolitan area'. The metropolis brings together both cities of Arnhem and Nijmegen as well as bordering municipalities to ensure cooperation in various areas including transport, economics, and housing.

The Waal River, which flows through the city, is the largest river in the country and one of Europe's main ecological and transport corridors. It is an accumulation of rainwater and melt water and

constitutes the principal distributary subdivision of the Rhine River flowing through the Netherlands, carrying over 60% of the total flow (Bernhard, et al., 2018; Martinez, 2018). During world war, the city was impacted and destroyed, and its reconstruction and restoration continued until the early 1980s. After this period, one of the biggest inland ports of the country developed in Nijmegen. A filmed report published online by the municipality of Nijmegen (2019a) affirmed that the port made the Waal one the busiest waterways in Europe, influencing with it the establishment of heavy industry and bringing an important economic value to the city which become a transit hub between industrial regions in the West Germany and the Dutch ports of Rotterdam and Amsterdam.

Today, Nijmegen is a vibrant city covering an area of 57 km² and is home to approximately 177,350 inhabitants according to population figures by the municipality of Nijmegen (2021). The Radboud University, established in 1923, attracts a large student population which adds to the city's dynamism.

Forecasts predicts that the city's population will keep on growing in the coming decades to exceed 200,000 inhabitants affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). "For this reason, the city is investing in ensuring new residential developments on both sides of the Waal River", he elucidated. The south of the Waal River presents the completely urbanized territory of the city of Nijmegen, while the north of the Waal, which is partly agricultural, is expected to be urbanized to accommodate the population growth (*figure 21*). The city's western area houses a large industrial site to which environmental problems such as noise and air pollution have been attributed (Environmental researcher at the Radboud University, interview, 2020).

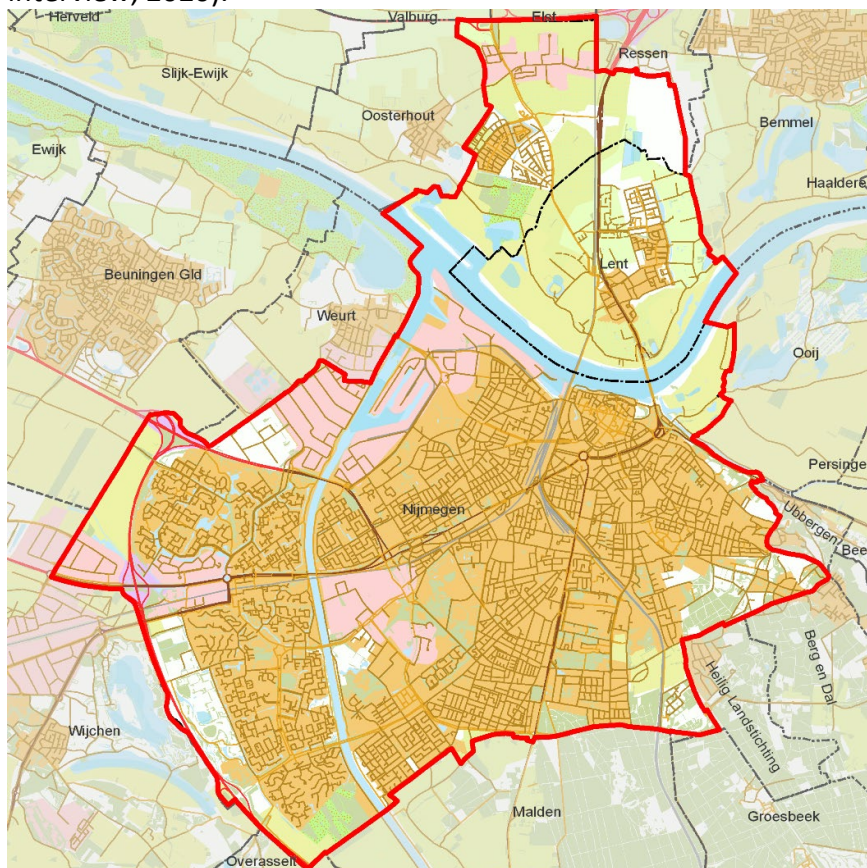


Figure 21 The city of Nijmegen. Source: BAG Woonplaats, 2012.

The Netherlands has a maritime climate influenced by the Atlantic Ocean and the North Sea. Since the country is small, climate variations from a region to another are minimal. Yet, maritime influences are less marked inland in areas like Gelderland, the province in which Nijmegen is situated. This area is one of the warmest areas in the Netherlands with a climate that corresponds to the weather conditions of Central Europe. Gelderland's climate is characterized by cold and wet winters and warm summer months with some rainy days. The city of Nijmegen has an oceanic climate (Cfb) as classified by the Köppen-Geiger system with temperate and warm weather. The examined Dutch city is already facing negative impacts of climate change including heavy rains in winter and heat stresses in summer. These effects are expected to increase in the light of climate change affirmed an environmental researcher at the Radboud University (interview, 2020).

4.2.1 Understanding the Impacts and Vulnerabilities: History of floods and new challenges on the horizon

The Netherlands is particularly vulnerable to climate change as about one-third of the Netherlands lies below sea level. A Dutch National Adaptation Strategy (NAS) was developed in 2007 providing insights into the most important (positive and negative) effects of climate change on the country. In 2012, Deltares, an independent institute for applied research in the field of water, calculated the cost of the damage that can occur due to climate effects such as flooding, drought, and heat stress. In 2016, an updated version of the NAS (Synergos Communicatie & Zegge en Schrijve, 2016) was published based on new insights.

According to the National Adaptation Strategy (NAS), the average temperatures increased by 1.8 ° C, twice as fast as the world average since 1900 and the annual amount of rainfall increased by 27 % between 1910 and 2015. Also, the intensity of heavy showers has increased with the increase in the frequency of hailstorms as well as a rise of 20% of precipitation leading to floods. At the same time drought is now a bit more common than in 1951 (Synergos Communicatie & Zegge en Schrijve, 2016).

The NAS exposed and detailed the impacts of climate change on various sectors. It underlined that this global phenomenon increases health problems risks (e.g., allergies, skin cancer, the spread of viruses, etc.), and affects the performance of individuals and their productivity. It elaborated that extreme weather conditions could lead to the failure of vital infrastructures and services including water chain, transportation, and energy systems, and in the long-term lead to damages to the built infrastructure systems and increase the chance of large-scale failures of electricity networks or Information Technology (IT) services due to extreme weathers (Synergos Communicatie & Zegge en Schrijve, 2016).

Additionally, it asserted that climate changes could lead to the reduction of yields and/or the quality loss of crops and could lead to the changes in the composition of flora and fauna (e.g., the disappearance of indigenous species or/and the invasion of new species) which could impact the economy, and the health people and animals (Synergos Communicatie & Zegge en Schrijve, 2016). The NAS also shed the light on some of the positive impacts of climate change on the Netherlands. For instance, it underlined that the rise of temperatures could have positive effects on tourism and some positive impacts on human health as the number of diseases and deaths from the extreme cold can decrease. Softer winters also lead to lower energy consumption for heating homes and

offices. Dutch agriculture has an advantage in comparison to southerly nations as the rise of temperatures can be beneficial and could offer new opportunities to produce crops.

Given the uncertainty of the future of climate conditions, the Royal Netherlands Meteorological Institute (KNMI) in coordination with the Dutch ministry of infrastructure and the environment developed a scientific report (van den Hurk, Siegmund & Klein Tank, 2014) presenting four climate scenarios for the country. All these scenarios show that the country will face significantly wetter and less cold winters. According to the report (van den Hurk, Siegmund & Klein Tank, 2014), an increase in average temperature between 1.0 and 2.3 ° C is anticipated and a sea-level rise from 15 to 40 centimeters as well as an increase of annual rainfall between 2.5 and 5.5% by 2050 are expected in comparison to the period 1981-2010. The KNMI climate scenarios predict an increase in the intensity of heavy rains hailstorms and the number of lightning strikes as well as an increase in strong gusts of wind by 10 to 15 % per degree of warming. Drought periods are also expected to be 5 to 25 stronger around 2050 in comparison to the period 1981-2010 (van den Hurk, Siegmund & Klein Tank, 2014).

The report on risks and opportunities linked to climate adaptation in the Netherlands (Ligtvoet, et al., 2015) developed by the PBL Environmental Assessment Agency affirmed that Delta scenarios consider demographic factors such as population growth and age especially that the aging of Dutch society increases its vulnerability to heat stress and diseases. These scenarios also include the evolution of the income per capita as well as the densification of a city which impacts its susceptibility to climate events (Ligtvoet, et al., 2015). Not to mention, the growing dependence of businesses and citizens on Information and Communication Technology (ICT), electricity and transport could make societies more vulnerable to disruptions in the light of climate change, especially that these services are becoming more interwoven (Ligtvoet, et al., 2015).

Given that the climate is now changing faster and to a greater extent than expected, the cost of the damage is likely to be higher (Synergos Communicatie & Zegge en Schrijve, 2016). As a case in point, the cost of the damage from the heavy rain and hail precipitations, which occurred in June 2016 in the south of the Netherlands, amounted to more than 700 million euros (Synergos Communicatie & Zegge en Schrijve, 2016). The report on risks and opportunities linked to climate adaptation in the Netherlands (Ligtvoet, et al., 2015) asserted that more attention is needed for future challenges as the country is majorly attuned to existing challenges. If we do nothing, the damage in our cities can amount to around € 70 billion in the period up to 2050” affirmed the Dutch ministry of infrastructure and water management (2019) in its report on spatial adaptation.

A climate adaptation knowledge portal³⁶ was established in the Netherlands in 2014 bringing together various sectors and existing networks from different regions, to support the delta plan³⁷ on spatial adaptation and the national adaptation strategy through providing information and allowing for knowledge sharing. “To accelerate spatial adaptation, it is important to share the available knowledge, tools and experiences as much as possible, so that not everyone has to

³⁶ <https://klimaatadaptatienederland.nl/>.

³⁷ The delta plan is established by the Dutch government to ensure that the country is protected against flooding, now and in the future, and prepared for weather extremes.

reinvent the wheel” affirmed the Dutch ministry of infrastructure and water management (2019) in its spatial adaptation report.

It has been agreed in the Delta Plan on Spatial Adaptation that by 1 January 2020 all governments will have to identify vulnerabilities and opportunities for climate change.

The NAS (Synergos Communicatie & Zegge en Schrijve, 2016) helped Gelderland build an improved understanding of (positive and negative) impacts of climate change as well as its ramifications on different sectors at a provincial scale, asserted a climate adaptation strategist at the province of Gelderland (2020) in an interview. He elaborated that, in collaboration with municipalities, water boards, and other parties, “meetings and workshops were organized to develop an environmental vision and define various ways to approach the assessed impacts”. The province is also aiming on mapping vulnerabilities to climate change and identifying opportunities by 2020. Some of the opportunities are linked to warmer summers as the province and the country are likely to attract more tourists as the weather could seem more pleasant according to the province of Gelderland (2018) in its publication on spatial response to climate change.

In 2017, the province of Gelderland set up the ‘Gelders Platform for Spatial Adaptation’ to share knowledge and experiences in the field of climate adaptation.

The city of Nijmegen is continuously working on improving its knowledge of the impacts of climate change through developing maps and studies at a local scale affirmed an adaptation policy advisor at the municipality (interview, 2020). He explained that, for instance, a map was developed presenting the principle green infrastructure and ecological corridors, distinguishing ecological hotspots, urban green areas and parks, water systems, flood plains, and open green areas. Additionally, an urban climate map was developed showing areas susceptible to the UHI effect (*figure 22*) and a rainwater flow map (Strating & Eijkelkamp, 2014) was created defining the parts of the city that are vulnerable to flood. Maps are also created to identify the vulnerability and the likelihood of the severity of drought in natural wet areas at a local scale (*figure 24*).

“The mapping of impacts and vulnerability allows determining the sites that are at risk” expressed the adaptation policy advisor at the municipality (interview, 2020), elucidating that the old areas of the city of Nijmegen are particularly vulnerable to the impacts of climate change. Bernhard, et al. (2018) avowed that “19th-century urban districts such as Nijmegen’s city center are at risk due to being densely built-up and paved over with little vegetation”. Moreover, the eastern and southern parts of the city are likely to be affected by the rise of groundwater levels (Bernhard, et al., 2018). Furthermore, the sectors that are vulnerable to the impacts of climate change in the city of Nijmegen have been defined by the European Environment Agency (n.d.) on its climate adapt platform, these include urban planning and construction, energy, health, biodiversity, transport, and water management.

Heatwaves and Urban Heat Island Effect

The Netherlands is becoming more prone to heat waves. In cities, this impact is more noticeable asserted the PBL Environmental Assessment Agency in the Netherlands in its report on risks and opportunities linked to climate adaptation in the country. The report (Ligtvoet, et al., 2015) clarified that in the short and medium run, the number of Dutch citizens experiencing the impacts of heat is likely to increase; firstly, because heatwaves are likely to be more frequent and more

severe. Secondly, the number of people living in cities is expected to increase. Thirdly, the aging of the population makes it more vulnerable to heatwaves given that elderly and people with chronic diseases are more vulnerable than others to urban heat stress which could increase the risks of diseases and lead to premature mortality (Ligtvoet, et al., 2015).

The Dutch environmental assessment agency's report explained that the development of green and blue infrastructure and certain technologies like air conditioning could have a preventative effect or limit this impact. Nonetheless, it is important to consider the right solution as infectious diseases could develop in wet areas, and technological systems like air conditions are not sustainable as they are highly energy-dependent and contribute to air pollution (Ligtvoet, et al., 2015).

A press article (AFP, 2019) indicated that in July 2019, temperatures reached new records in the Netherlands as 40.4 degrees Celsius were recorded, marking it the first-time temperatures rise above 40 degrees in the country. The article (AFP, 2019) explained that mortality rates in the last week of July that year increased by 400 people in comparison to an average week in the summer because of the extreme heat, and most of these people were elderly.

An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) highlighted that heat stress is relatively a newly felt impact in Nijmegen. He explained that the Dutch people and the residents of Nijmegen have been more used to dealing with storms and flood-related issues, however in the past couple of years city residents witness exceptionally hot summers. "The city is therefore still in the process of understanding what this could imply" asserted the adaptation policy advisor (interview, 2020) explaining that "there are uncertainties when it comes to the future of heatwaves and UHI effect in the city, but it is expected that Nijmegen will witness hotter summers as well as longer and more recurrent heatwaves". The municipality is aware of the importance of preparing for the future and addressing the issue of climate change at a local level in a context where extended heatwaves are expected to be more frequent, asserted the European Commission (2017) in a report entitled 'Nijmegen European Green Capital 2018' developed in the context of the municipality application to the European Green Capital award.

The figure below (*figure 22*) presents an urban climate map presented by the municipality of Nijmegen (2017) in its application for the European Green Capital award 2018 to demarcate the areas that are susceptible to the UHI effect. The map demonstrates that the city center is the overheated zone that is most vulnerable in the event of heatwaves. Likewise, various neighborhoods around the center are susceptible to the UHI effect like Altrade, Galgenveld, Bottendaal, Biezen as well as 'Hatert' in Nijmegen-Zuid. The northern part of the city (north of the Waal), which is partly agricultural, presents a fresh and cool air protection zone and is the one that is the least impacted by the UHI effect.

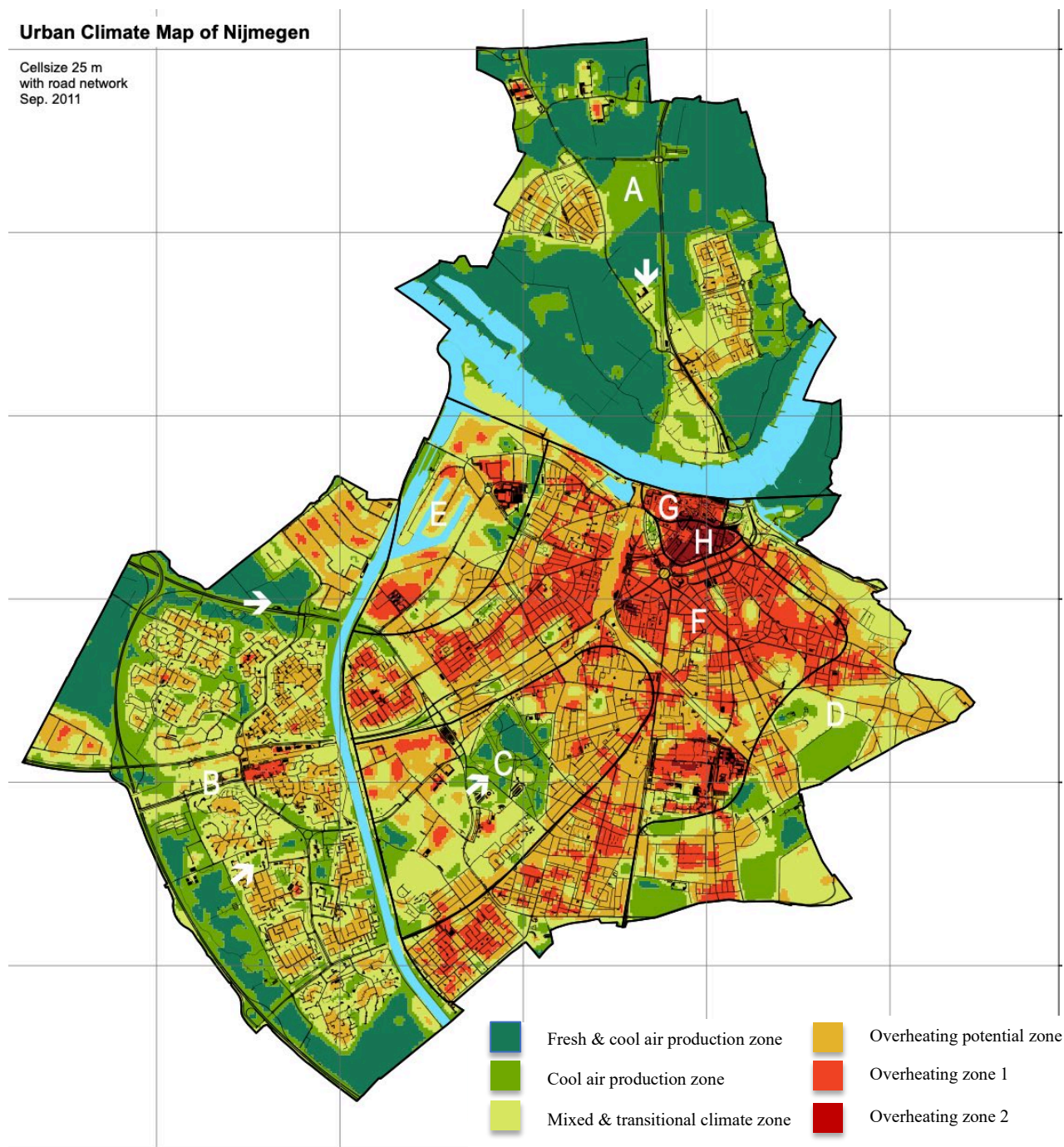


Figure 22 Urban climate map showing areas susceptible to UHI effect in red. Source: Municipality of Nijmegen, 2017.

Heavy Storms and Flooding

The Netherlands is particularly vulnerable to inundations due to the rise of sea level given that almost a third of its territory is low-lying. In 1953, the country was flooded due to a major storm combining high tides, strong winds, and low pressure, leading to a rise of water levels by more than 5.6 meters above sea level. Consequently, more than 130,000 hectares (340,000 acres) were flooded, around 100,000 people were displaced, more than 47,000 buildings were damaged and over 1800 person lost their lives in the country (Hall, 2013). This event had a more direct impact

on coastal Dutch cities and did not directly impact the inlands. The flooding of the Rhine River in the years 1993 and 1995 (*figure 23*) was nonetheless a “wake up call” to the national and regional authorities and an alert that the North Sea wasn’t the only cause of the problem. This event underlined the importance of addressing river flooding as well (Martinez, 2018). The inundation of the Rhine was a major threat to Nijmegen and the surrounding area as in 1995 around 250,000 people were evacuated from their homes (Carlier, 2016; Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).



Figure 23 The Rhine River flood at high water in Nijmegen in 1993 and 1995. Source: Verhoeven, 2017

Nijmegen is one of the cities that has suffered the most severe floods in the country and is aware that the risk of inundation will increase due to climate change (Carlier, 2016). The municipality of Nijmegen (2017), in its application for the European Green Capital award, underlined that in 2009, the city experienced heavy rainfalls and several streets in the center and the east of the city was swamped. Since the municipality developed an improved understanding of the risk and residential projects in vulnerable streets began to ensure the prevention from future damages in 2012 due to the provision of practical tools allowing residents to make their dwellings ‘waterproof’ affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). He asserted that new districts, constructions, and residential developments are made waterproof such as the new neighborhood developed north of the river. However, he underlined that it remains a great challenge to increase the resilience of the old city center to floods.

According to a study (Bernhard, et al., 2018) on the adaptation of Nijmegen to climate change, the expected increase in rainwater affects groundwater levels, which may lead to issues in built infrastructure (e.g., mold) and affect the health of residents. Moreover, the issue could have

severe impacts on agricultural and natural areas (Bernhard et al., 2018). Not to mention, it could lead to the mixing of groundwater and surface water with sewage water which, on one hand, increases the stress on the sewage system, and on the other hand, impacts water quality. When the wastewater becomes more diluted, it is more challenging to treat it as the purification system of the water authorities functions best with higher concentrations (Bernhard, et al., 2018). Additionally, In the summer, the frequency of heavy rainfalls is expected to rise, which makes the city susceptible to floods and the fast spread of infectious diseases due to elevated temperatures (Ligtvoet, et al., 2015).

Droughts and Reduced Water Availability

The Netherlands has a primary focus on preventing flooding as well as dealing with wetness and is not accustomed to dealing with drought, however, the Royal Netherlands Meteorological Institute (KNMI) in its scientific report (van den Hurk, Siegmund & Klein Tank, 2014) anticipated that as of 2040, the country will be likely to face considerable problems with regards to the availability, quality, and supply of freshwater.

The 2018 record drought was proof that the country is not exempted from dealing with reduced water availability. A press article (Newmark, 2019) shed the light on the fact that the KNMI foresees that the country will be dryer in the coming years. The article presented that, according to researchers from the University of Utrecht, droughts like the one seen in 2018, previously predicted every four or five decades, is now expected every decade or two. It elaborated that the serious drought experienced in 2018 caused a series of problems for the agriculture and shipping sectors as well as workers in the construction field and homeowners. The press release (Newmark, 2019) affirmed that researchers believe that the country is not addressing the issue of reduced water availability aggressively. In 2019, the water levels marked a deficit, which demonstrates that the country had not recovered from the dry season of 2018. Nationwide, by the end of March 2019, the average rainfall deficit was at 64 millimeters. The situation shows that agriculture problems could aggravate (Newmark, 2019). The release of such articles in the press is crucial to underline the impacts of climate change on various sectors and raise the awareness of the public on the matter. In this context, it is also important to underline that, droughts not only affect water quality and crops but also could lead to large-scale power failures as presented by PBL Environmental Assessment Agency in the Netherlands in its report on climate adaptation risks and opportunities (Ligtvoet, et al., 2015).

A climate adaptation strategist at the province of Gelderland (interview, 2020) affirmed that a new working team has been recently established at the scale of the territory to investigate the risks of drought at a local scale as well as related issues.

The vulnerability of wet nature areas to drought (*figure 24*) was defined and presented by the municipality of Nijmegen (2017) in its application for the European Green Capital award 2018. The areas highlighted in purple show a severe vulnerability, the ones in red show a medium vulnerability, the areas in orange depict a slight vulnerability and the ones in yellow portray no vulnerability. The areas highlighted in blue are the ones with an unknown vulnerability to drought.

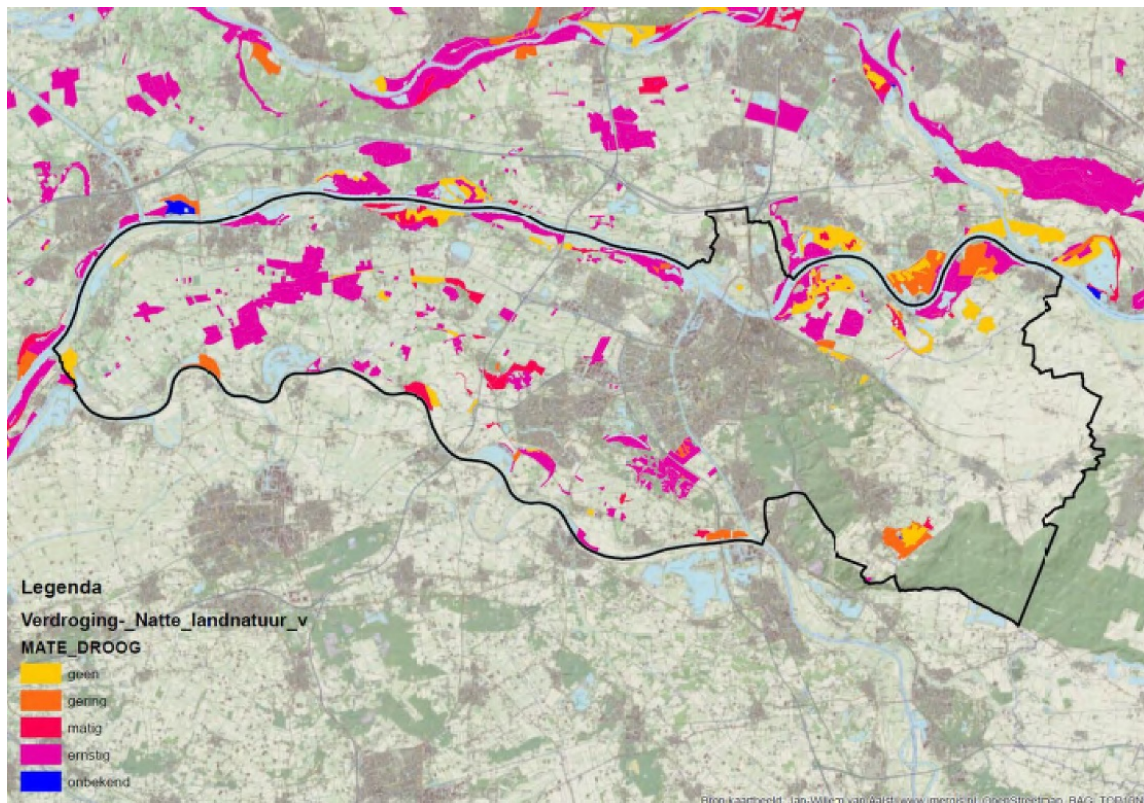


Figure 24 Vulnerability of wet nature areas to drought. Source: Municipality of Nijmegen, 2017.

4.2.2 Developing Adaptation Strategies: Mainstreaming adaptation into various policy plans

In the Netherlands, the 1953 floods, resulting in more than 1800 deaths, triggered a proactive risk management policy to respond to citizens' expectations of safety given that 60% of the territory is vulnerable to being inundated from sea or rivers. Most adaptation policies in the country are therefore based on flood protection (Caude, et al., 2015). The Dutch government is engaged in a strategy of strong anticipation since it has developed a prevention plan spread over forty years with high-risk assumptions (Caude, et al., 2015).

At the country scale, a NAS was first published in 2007, with the input of the Dutch provinces particularly on water management (Lukat et al., 2016; Caude et al., 2015). In parallel, in the same year, the national government started with the development of the "Room for the River" program to prevent the flooding of urban areas by suggesting a new approach that promotes the broadening of flood plains in contrast to the traditional approach of building and raising dikes. Throughout the country, more than 30 river-widening projects were developed.

The Adaptation Action Plan, known as the Delta Program, was initiated in 2010. The main approach to adapting the country to climate change include plans and measures to ensure flood safety such as dike reinforcement, urban development plans, sand replenishment as well as plans to ensure a sufficient freshwater supply for present and future generations (e.g., water storage and desalinization) (Lukat et al., 2016; Caude, et al., 2015). The Delta program, updated yearly based on new insights, have allowed the Netherlands to move forward towards increasing the climate

resilience of the country affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). The 'Delta Act', which came into effect at the beginning of 2012, is the legal basis for the national adaptation program. It sets the role of the Delta Commission and creates a fund with a minimum of one billion euros per year as of 2020 to implement the Delta program (Caude, et al., 2015). The national adaptation approach focuses mainly on water management and flood protection and does not elaborate much on all the opportunities and risks in relation to changes in climate (Litgtvoet, et al., 2015; Caude, et al., 2015).

In the context of the climate agenda examined by Parliament in October 2013 and in response to the call of the European Commission to adopt a comprehensive climate adaptation strategy by 2017, an updated national adaptation strategy (NAS) was developed in 2016 building on acquired knowledge and existing initiatives such as the Delta Program.

In 2017, the Delta Commission launched the first Plan on Spatial Adaptation as part of the annual Delta program. This plan presents an administrative arrangement between central government, provinces, municipalities, and water boards to speed up and intensify adaptation to climate change to reduce the effects of heat stress, drought, and floods through addressing these issues in territorial planning. The Dutch ministry of infrastructure and water management (2019) asserted in its spatial adaptation report that all levels of governments should ensure that the damage caused by climate events is as little as possible. It stated that climate adaptation must be included in guidelines and policies of the central government, waterboards, provinces as well as municipalities. It also avowed that, key actors are responsible to integrate delta plans when developing new residential areas and industrial estates, renovating existing buildings, replacing sewerage systems, and maintaining the existing infrastructure, detailing that "climate change requires a change in thinking: setting up climate-proof and water-robust must become a natural part of spatial (re) developments".

The Delta Plan detailed that all levels of governance are required to conduct risk dialogues and prepare implementation agenda before the end of 2020. It is nonetheless important to highlight that "many regional and local governments were already working on understanding impacts and developing climate adaptation responses before the delta decision" (Climate adaptation strategist at the province of Gelderland, interview, 2020).

From the statutory duty, the province is responsible for sustainable spatial planning and the insurance of public housing, clean water, a healthy environment and the construction and maintenance of provincial roads, bridges, and viaducts. It should pay explicit attention to climate adaptation and translates this into instruments and environmental regulations asserted a climate adaptation strategist at the province of Gelderland (interview, 2020).

In its publication on spatial response to climate change, the province of Gelderland (2018) made the distinction between climate mitigation and adaptation and linked these actions with sustainability. It asserted that adaptation actions are included in the elaboration of the core tasks of the province's programs and deliberately did not opt for an independent program for adaptation.

In 2017, the Province of Gelderland developed a Regional Adaptation Strategy (RAS) in arrangement with water authorities, the city of Nijmegen and other municipalities. At that time,

Gelderland was the first Dutch region in which local and regional authorities collaborated to examine the threats of climate change in urban and rural areas affirmed a climate adaptation strategist at the province of Gelderland (interview, 2020). In this context, small municipalities around Nijmegen joined efforts to develop a 'Risk and Opportunities report' identifying vulnerabilities, weaknesses, and opportunities. The RAS is based on the ambition of adapting the region to climate change by 2035, and no later than 2050.

The budget distribution per theme (*figure 25*) retrieved from the regional climate adaptation action plan developed by the province of Gelderland (2021) to complete the regional adaptation strategy, shows that the largest budget is dedicated to measures addressing the issue of heat stress (40% of the total budget). The second largest budget, accounting for 20% of the total budget, is set to ensure climate-proof (re)building. The budget dedicated to greening cities and villages of the province and the budget defined to developing natural soil and water systems as a basis to address climate issues are each equal to 15% of the total budget while only 10% of the budget distribution is dedicated for ensuring and developing climate-proof provincial roads. This shows that the province is largely investing in addressing heat-stress issues through greening cities, developing nature-based solutions and water systems.

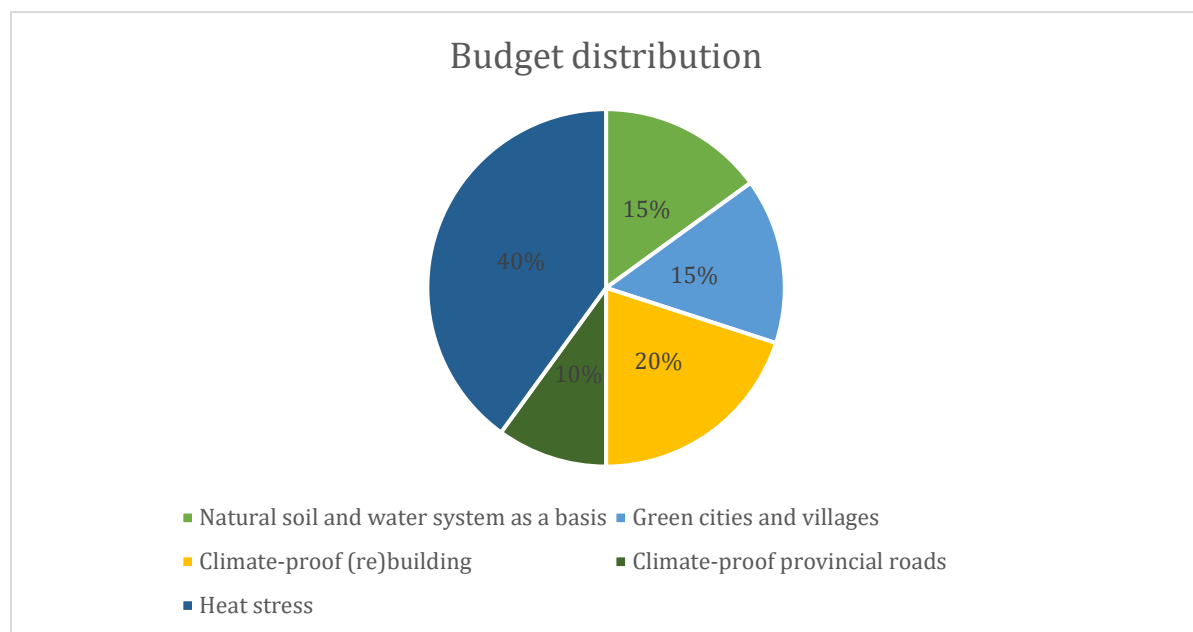


Figure 25 Budget distribution per theme as retrieved from the Climate Adaptation Action Plan (program) towards a climate-proof Gelderland Coalition (Province of Gelderland, 2021).

Following the high river discharge incidents in 1993 and 1995 leading to the evacuation of over two hundred thousand people in Nijmegen, the city made policy changes and decided to work in collaboration with its water partners to ensure a more sustainable water chain, a resilient water system and a healthy and attractive living environment (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Consequently, the city adopted a new approach to dealing with heavy precipitations which consist of retaining and storing water then discharging the excess in contrast to the traditional approach -entailing the discharge of water surplus to the sea straightaway (Bernhard, et al., 2018). This newly adopted approach is based on 3 steps. Firstly, it consists of containing precipitated water in the area in which it falls. Secondly, the water is stored

in ponds or collectors when the local capacity reaches a maximum. Thirdly, the water is channeled and drained, but this step is only implemented if the sewer or the river would be flooded otherwise (Bernhard, et al., 2018).

In 2001, the city adopted its 'Water Plan' in which it proposed disconnecting the paved surface to allow rainwater to filter into the soil rather than mixing with the sewage system. The objective of this initiative is twofold, affirmed the municipality of Nijmegen (2017) in its application for the European Green Capital Award 2018. First, it reduces the vulnerability of the city to floods due to heavy rainfalls. Second, it separates water at the sources, instead of requiring more energy to purify the water at a later stage.

In Nijmegen, the room for the Waal program was established to increase the river's discharge capacity as an appropriation of the national 'Room for the river' program. This decision was based on calculations that showed that peak discharges of the Waal River are expected to cause a threat to the city of Nijmegen in the light of climate change affirmed an environmental researcher at the Radboud University (interview, 2020). Accordingly, political discussions were conducted between different levels of governance (national, provincial, and local) to address various concerns such as water safety, the development of infrastructure, and the involvement of stakeholders. In 2007, a political agreement was reached to develop an integrated plan which considers various perspectives and combines various budgets affirmed the Municipality of Nijmegen (2008) in a newsletter about the dike relocation. The newsletter explained that the spatial plan proposes a dike replacement project based on an environmental impact assessment to weigh the effect of this project on the ecosystem. The project's master plan focuses on architectural and spatial quality through providing multifunctional spaces and building with nature. The municipality (2008) affirmed in its newsletter that it didn't want to be the sole participator in formal steps and wanted to have a broader conversation with interested parties about the opportunities for the area. Consequently, a participation process was established to include entrepreneurs and inhabitants in the development of the plan.

A Nijmegen climate consultant (interview, 2021) clarified that the Waal adaptation project stresses the fact that flood risk management has always been important to the city. "This is clearly different with regards to heat stresses" he affirmed. He elucidated that the regional adaptation strategy has paid attention to heat stress; however, the local impact has not yet been worked out and no specific measures are developed to address this stress.

The municipality also has the ambition of making Nijmegen a greener city. No legal requirements were set to define the spread and the number of green areas. However, in 2007, a 'green policy' was presented in the plan 'The Green Wire' (De Groene Draad), outlining frameworks and opportunities for increasing the share of greenery in various districts in the city.

The municipality of Nijmegen (2017) asserted in its application for the European Green Capital Award that green and blue infrastructure systems should consider various elements including social cohesion, public health, leisure, and climate. To assure the development of urban green and blue spaces, resident groups are actively involved and are consulted for public investments.

An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) stated that in 2008, the city council developed a "Climate Framework Memorandum" determining the municipality's energy and climate objectives which include establishing a climate-neutral organization by 2015 and increasing the share of renewable energy to assure a climate-neutral city by 2032.

A sustainability agenda (2011-2015) was developed by the municipality in 2011 presenting 5 bases (Verhoeven, 2017). First, it proposes ensuring an energy-neutral city by developing sustainable sources of energy and promoting energy savings. Second, it aims at developing a climate-neutral organization by promoting sustainable purchases. Third, it wants to create green employment and stimulate innovation and invention in the area of sustainable energy to promote a sustainable economy (Verhoeven, 2017). Fourth, the municipality plans on focusing on urban distribution, investing in public transport and bikes, and ensuring a “green” transportation fleet to promote sustainable mobility. Fifth, it aims at endorsing sustainable urban developments and emphasizing nature-based solutions based on an ‘Ecopolis Vision³⁸’ by working on compact urbanization, promoting sustainable constructions, and developing climate-proof districts (Verhoeven, 2017). The city also developed an annual implementation program (2013-2017).

To make the city climate-resistant by 2050, Nijmegen engaged itself in various projects, including the application for the European Green Capital award in 2018 (environmental researcher at the Radboud University, interview, 2020). It is also a member of the Mayor’s Adapt initiative and has in place plans that align well with the environmental objectives at the local, regional, national, and EU levels (e.g., 7th Environmental Action Program³⁹).

An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) stated that the city does not have a proper adaptation plan yet, since it has worked closely with the province of Gelderland and water authorities in the development of the RAS. He explained that the city’s adaptation policy is encompassed in the present policy plans (on greenery, water, and sewage system) which protects its vulnerability to heat stress and heavy rainfall. He nonetheless affirmed that the municipality wants to develop its proper adaptation plan by the end of 2021.

“The majority of key local actors are aware of the importance of addressing the issue of climate change and work towards achieving sustainability” affirmed the adaptation policy advisor at the municipality of Nijmegen (2020) in an interview, elaborating that “the mayor and the vice mayor are behind of the city’s green ambition and their support was essential in the context of the application of the city of Nijmegen to the European Green Capital award for the year 2018 (EGC2018)”. An environmental researcher at the Radboud University (interview, 2020) stated that over the past 16 years, the city of Nijmegen had aldermen responsible for sustainability, environment and climate who assured the continuity of actions. He explained that in Nijmegen the steadiness of climate policies is ensured not only due to the stable political climate but also because of the strong position of civil society and NGOs.

The timeline of strategy development serving climate adaptation in Nijmegen (*figure 26*) shows that there is coherence and harmony in environmental and climate actions between various levels of governance. The national strategy is serving as a backbone, but it is not dominating the efforts taken at subnational levels. For instance, the city of Nijmegen started with the construction of the

³⁸ The Ecopolis approach puts the environment at the heart of the development of cities. It considers that an ecological culture is crucial to a healthy urban environment. This approach considers cities an opportunity for ecological restoration (by bringing back nature to cities) instead of an agent of environmental degradation (Downton, 2009).

³⁹ The 7th Environment Action Program (EAP) served as a guide for the European environment policy until the year 2020.

room of the Waal project in 2011 in coordination with water boards, as an appropriation of the room for the river program which was initiated by the national government in 2007. Additionally, the municipality was able to offset developing its proper adaptation plan as it has been working closely and in parallel with the regional level in the development of a regional adaptation strategy. Nijmegen has however been engaged for over a decade and a half in environmental and climate action as the council developed a water plan, a ‘climate framework memorandum’, a green policy plan, and a sustainability agenda. Not to mention that its first efforts preceded or coincided with the development of environmental and climate strategies and plans at a national level which shows that the city is actively taking action to address the matter. The case of Nijmegen presents an example balancing out top-down and bottom-up governance approaches to climate adaptation.

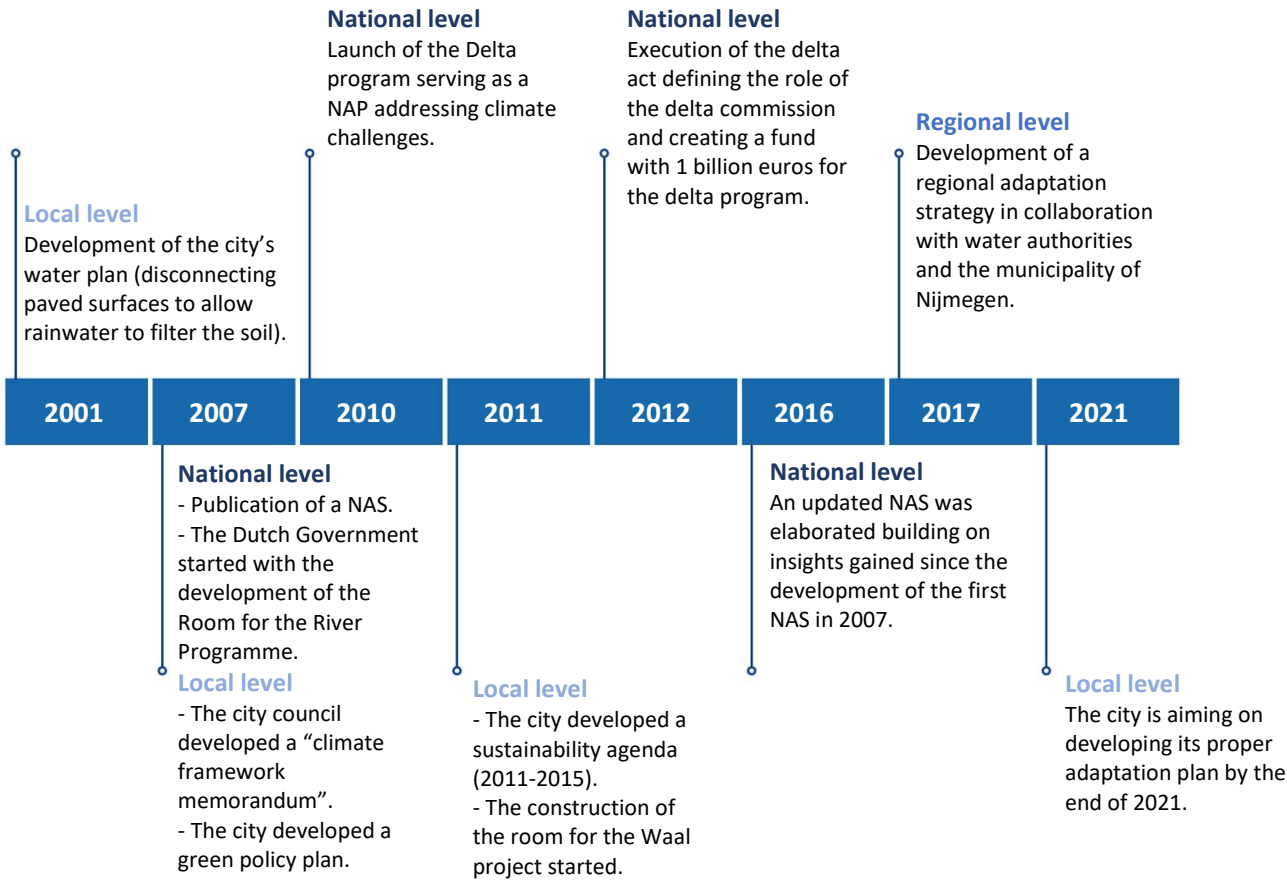


Figure 26 Timeline of strategy development at a national, regional, and local scale serving climate adaptation in Nijmegen.

4.2.3 Implicating and Mobilizing Actors: Profiting from the EGC2018 event to engage various actors

The PBL-Environmental Assessment Agency in the Netherlands, in its report on risks and opportunities linked to climate adaptation in the country, asserted that the protection of the main infrastructure systems, including ICT, energy, and transportation, is the responsibility of the national government. However, ensuring the climate resilience of other main infrastructure systems necessitates collaborative efforts (Ligtvoet, et al., 2015). National, regional, and local governments are all responsible for climate adaptation especially in areas like nature conservation, public order, and public health but are not the sole actors (Ligtvoet, et al., 2015). The national

government is actively working to orchestrate processes of climate adaptation between various actors including governmental agencies, the private sector, independent governing bodies, and NGOs (Ligtvoet, et al., 2015).

“The style of the governance in the Netherlands is based on collaboration and increasingly considers an integral less hierarchical approach” stated an adaptation policy advisor at the municipality of Nijmegen (interview, 2020), affirming that “it is shifting towards networking and participation rather than a ‘lawful’ approach”. A participatory society culture is dominant as businesses and citizens have more responsibilities and are increasingly taking the initiative to improve the environment. As a case in point, a collaborative decision-making approach and participative research conducted between 2010 and 2014 were the basis of the delta program aiming at increasing the resilience of the country to climate change (Ligtvoet, et al., 2015).

On its online platform, the government of the Netherlands (2014) declared its ambition in assuring the collaboration among different parties including governments, businesses, knowledge institutions, educational establishments, and CSOs to make sure that by 2050, Dutch urban areas will be equipped to tackle the consequences of dry spells, heat, and flooding. This ambition has been set out in a Declaration of Intent which was signed during the Spatial Adaptation Festival which took place in Utrecht, October 9, 2014 (Government of the Netherlands, 2014).

The province of Gelderland is not actively responsible for the implementation of adaptation strategies (Bernhard, et al., 2018). It works mostly on knowledge dissemination, establishing links between the state government, local municipalities, and other actors, as well as sharing good examples and best practices. It also guides and advises the water authorities or the municipalities on ways to improve the developed plans (Climate adaptation strategist at the province of Gelderland, interview, 2020).

In collaboration with the Ministry of Infrastructure and Water Management, the province of Gelderland established an ‘Extreme Weather response Group’ to involve companies and citizens in climate action.

In its publication on spatial response to climate change, the province of Gelderland (2018) stated that it takes advantage of the occurrence of extreme weather conditions to make citizens and businesses more aware of the need for climate adaptation. It also underlined that it is also working closely with other Dutch provinces on climate adaptation, knowledge sharing, and developing insights about generic issues and more region-specific ones.

In Gelderland, various teams work on different topics and themes including heat stress, drought, and climate change affirmed a climate adaptation strategist at the province (interview, 2020), clarifying that there’s an employee at the province of Gelderland tasked to assure the coordination between various actors within the province and between the province and the municipality of Nijmegen, among others.

The national and regional water boards have the responsibility to protect surface waters, according to the Water Framework Directive and the Floods Directive. The province of Gelderland has the responsibility to protect the quality and quantity of groundwater, with respect to national and European regulations. Meanwhile, local municipalities (e.g., the municipality of Nijmegen) respect and implement these policies in their water policy and zoning plans. They are also

responsible for stormwater and sewer management (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Water authorities also work on involving various partners in the process of adaptation to climate change through developing awareness campaigns and communicating with businesses, insurance companies, architects, and citizens (Bernhard, et al., 2018).

Municipalities have an important and a large role in making spatial developments more climate-proof and developing local projects that help adaptation a little further (Ligtvoet, et al., 2015). An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) stated that many actors at the heart of the municipality work on adapting the city to climate change. He however elaborated that for other actors, such as businessmen or workers in the construction field, climate adaptation is not necessarily on top of their minds.

A study (Bernhard, et al., 2018), conducted to assess the involvement and participation of various stakeholders in adapting Nijmegen to climate change, showed that the division of responsibilities and tasks is rather unclear as no agreement or document of any kind defines the exact responsibility of each actor. This study affirmed that the municipality bears the responsibility to adapt public spaces to climate change, however, it doesn't consider itself accountable for ensuring the adaptation of privately-owned houses. It also asserted that citizens seem to be more interested in creating a livable environment (Bernhard, et al., 2018).

At the initiative of the political groups Groenlinks and PvdA, Nijmegen established a council to determine the city's climate ambitions. The council's role is to develop a concrete action plan to draw up a framework in collaboration with social organization, residents and the business community affirmed the adaptation policy advisor at the municipality of Nijmegen (2020) in an interview. He elaborated that the companies and citizens bear a great responsibility in the implementation of adaptation measures. Consequently, the municipality is working on the development of awareness, adequate communication, and the provision of relevant information. As a case in point, the "Power2Nijmegen" initiative, a network, bringing together over 250 organizations including companies, educational and research institutions, citizens, and administrations to ensure an "energy-neutral" city. This partnership allows addressing new topics such as 'circular economy' and 'bio-based' economy affirmed the Municipality of Nijmegen (2017) in its application for the European Green Capital Award.

It is nonetheless important to highlight that this initiative is focused more on ensuring sustainable development and reducing emissions rather than increasing the resilience of the city and adapting it to changes in climate.

Since the 1990s, the citizens have been involved in urban planning and their input has been apparent in the development of the city affirmed the European Commission (2017) in its 'Nijmegen - European Green Capital 2018' publication. The Hessenberg and the Dobbelman projects, presenting respectively a press printing site and a former soap factory, have considered the expression of the public requesting the incorporation of green spaces in the early development stages. The European Commission (2017) affirmed in its evaluation of Nijmegen's application to the EGC award that the city is making noticeable progress towards a more environmental-friendly future due to an integrated approach in which many projects and initiatives are developed and implemented across all sectors in tandem with educational institutes, businesses, and citizens.

The municipality sets up cooperation agreements with regional and local strategic partners. It is working with businesses and knowledge institutes, such as the Wageningen and the Radboud University, and the university of applied sciences, to ensure an energy-neutral and climate-proof city (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).

An environmental researcher at the Radboud University (interview, 2020) highlighted that the university and the municipality are cooperative on many fronts. He explained that many experts and students (in natural sciences and social sciences) at the university have been involved in research on Nijmegen and the region, and part of this research is funded by regional or local authorities. “The conducted studies cover a range of topics including environmental issues, climate policies, and strategies as well as the mitigation and adaptation efforts in place” affirmed the environmental researcher (interview, 2020). He also evoked that the city has a network of concerned people that gather and meet every month or two at the city’s cultural center. That “sustainability café” (as it is called by the group of concerned actors) brings together over a hundred participants each time to discuss and debate on a series of environmental themes. However, “the people that meet up monthly form a sort of a closed network who is already interested in the topic and bringing new people on board remains a challenge” elucidated the environmental researcher at the Radboud University (interview, 2020). Not to mention, the coronavirus pandemic impacted the organization of these events. This underlines the importance of reaching out to new individuals and suggests the digitalization of environmental discussions.

The Municipality of Nijmegen (2017) underlined in its EGC application that the city is engaged in various environmental and adaptation networks, projects, and initiatives allowing it to exchange knowledge with other cities and to build its capacity to support sustainable developments. Nijmegen signed the Mayor’s Adapt convention as well as the Declaration of Intent for Spatial Adaptation and joined the ICLEI network in April 2015. The city also participated in the ‘European Interreg IVB Future Cities Project’ which allowed it to exchange experiences and knowledge with various cities including the city of Rouen in France, the Dutch cities of Arnhem and Tiel, the city of Ypres in Belgium (Municipality of Nijmegen, 2017).

The RESIN (n.d.) consortium, consisting of scientists working on urban climate adaptation research, presented on its website that the realization process of the room for the Waal project involved elaborate discussions and collaboration with a wide range of stakeholders, and concerns were addressed. This was also affirmed by the EEA (2014) on its Climate Adapt platform presenting the ‘Room for the river Waal’ case study as it clarified that for the development of plans, the local community was engaged through information meetings, newsletters, and interactive workshops. In these workshops, plans were introduced so that they can be adapted based on the inputs given by participants. “Through the broad involvement of stakeholders and serious responses to their inputs, the stakeholders’ doubts and opposition were largely addressed” (EEA, 2014).

The European Commission (2017) in its evaluation of Nijmegen’s application to the EGC award stated that the EGC2018 jury members appreciated the engagement of the municipality with its citizens. “The Award Jury members were impressed by Nijmegen’s engagement with citizens, including its wide range of stakeholders, and how the city would act as an ambassador for the green city movement across Europe. The range of stakeholders invested in Nijmegen’s sustainability projects and European Green Capital bid ranged from businesses to research and educational institutes, local government to citizen-led networks and primarily, the very active and

involved residents” asserted the European Commission (2017) in its publication ‘Nijmegen - European Green Capital 2018’.

In the context of the application of the city of Nijmegen to the European Green Capital award for the year 2018 (EGC2018), the city set up a project team to put the EGC2018 program into practice. The city’s ambitions were supported by the municipality, the province, the Radboud University, and the HAN University of applied sciences as well as other business groups and research institutes affirmed an environmental researcher at the Radboud University (interview, 2020). He explained that the project team, partners as well as residents organized various events for public audiences and professionals, affirming that “the EGC event was a great catalyst for raising environmental cognizance in the city”. The municipality of Nijmegen (2019b) in its technical report presented to the EGC stated that a census conducted by the city panel showed that, due to the EGC application, the awareness of citizens has increased as 85% of residents were familiar with Nijmegen EGC2018 and 80% of them presented their appreciation or neutrality towards the city’s engagement in applying for the award. Additionally, more than 200 small and large congresses, as well as lectures and events, were held. 23 sponsors, 21 official partners, and 200 signatories supported the green capital manifest (Municipality of Nijmegen, 2019b).

4.2.4 Implementing Developed Strategies: National, regional authorities and waterboards offering financial support to implement spatial adaptation projects

In the Netherlands, an annual implementation program for the execution of the NAS has been established since 2010. The most prominent responses mainly concern the management of water and the risk of flooding including the retention and storage areas for surplus water, reloading sand beaches, the development of dunes and artificial reefs as well as the reinforcement of existing dikes and dams. A budget of € 2.5 billion covering the period 2009-2020 has been allocated, but it is considered insufficient to cover adaptation needs (Caude, et al., 2015). The costs of implementing the Delta program, built based on the worst climate scenarios, have been estimated at between 1.2 and 1.6 billion euros per year until 2050 and then between 0.9 and 1.5 billion euros for the period 2050-2100 (Caude, et al., 2015). The "Room for the River" program, which covers 40 interconnected infrastructure projects for € 2.1 billion, should also be added.

Even though the Netherlands deals more often with floods, in 2019, the government announced the allocation of 7 million euros to address the issue of drought in the country. The money is dedicated to monitor the levels of evaporation, to build bigger water reservoirs in permeable areas, and to diminish the impact of salinization of potable water (Newmark, 2019). Outside the water sector, little has been done in the fields of agriculture, forestry, fishing, transportation, or energy (Caude, et al., 2015).

“The Dutch city of Nijmegen is one of the major urban examples for the implementation of the ‘Room for the River’ project, introduced by the national government” affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). The project - costing over 250M euros - is considered one of the largest inland climate adaptation developments in the country and took 10 years to be completed stated the RESIN (n.d.) consortium of urban climate adaptation researchers on its online platform. The ‘Room for the Waal’ project meets national directives for coupling spatial quality with flood protection while ensuring water safety at a local scale indicated

an environmental researcher at the Radboud University (interview, 2020). He elucidated that the project was designed and calculated by top engineers of Dutch water management and was built based on different simulations and scenarios to increase the resilience of the city to floods. For this project, a dike was repositioned, 3 bridges and a new quay were constructed, and an auxiliary channel was developed to drain the river when there are high water levels, creating an island (*figure 27*). The latter presents an urban river park for recreational activities and the ancillary channel permits to lower the water level by 35 cm. According to the European Commission (2017) in its report 'Nijmegen-European Green Capital 2018', the room for the Waal project did not only ensure improved flood protection and adaptability to climate change but also created opportunities for new housing developments. Additionally, it ameliorated the spatial quality of the city as it offered a new river park for recreational use and for the citizens to enjoy.

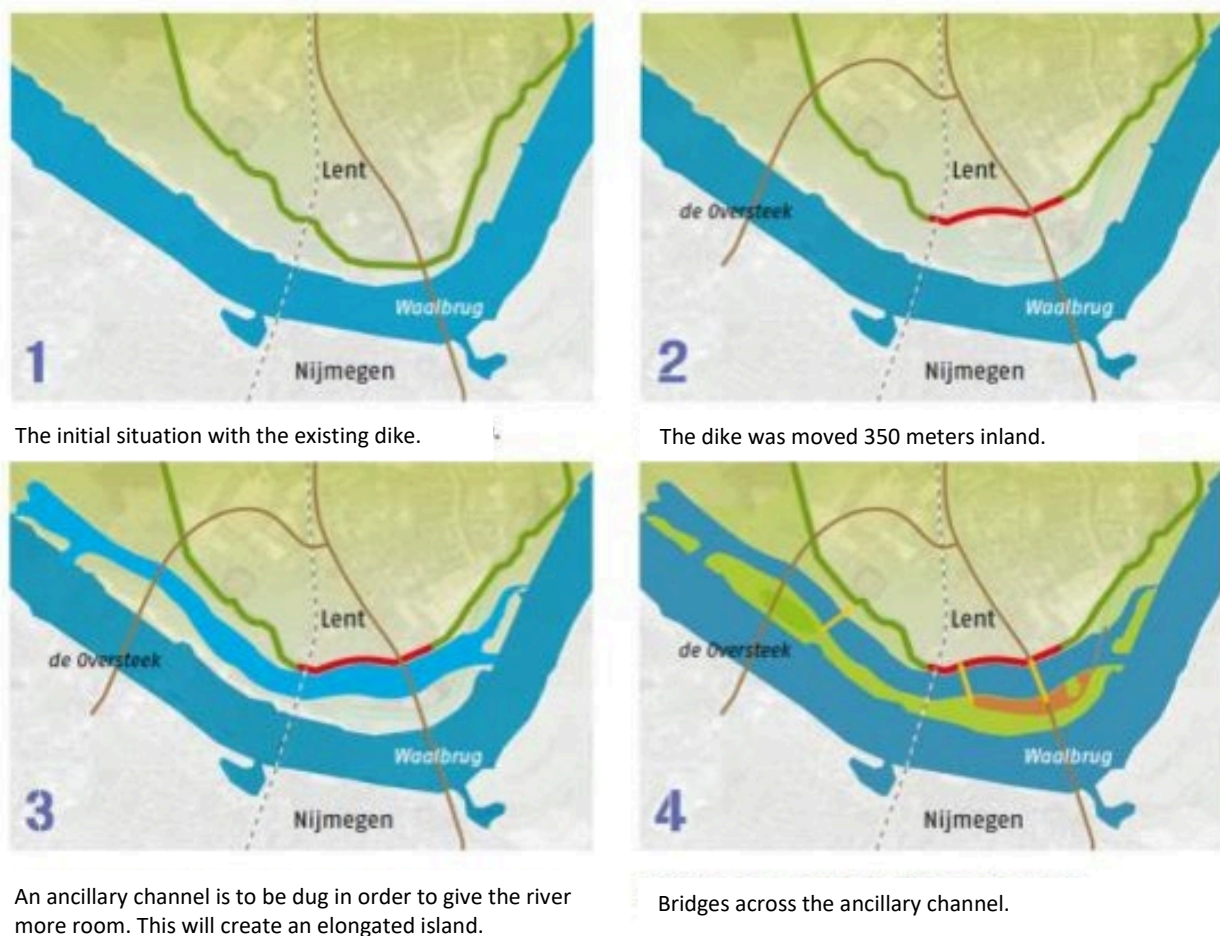


Figure 27 Room for the river Waal project. Source: Climate Adapt, n.d.

To increase its transparency, the city tries to involve the public as much as possible. An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) clarified that the participation of citizens is obligatory especially in the implementation of big projects. He asserted that “the implementation of the Room for the Waal at the scale of Nijmegen was a community-led project but would have not been possible without the support of the national and regional government”. This project played a great role in boosting the awareness of local citizens on the issue of climate change and the importance of adapting and increasing resilience asserted an environmental researcher at the Radboud University (2020) in an interview. He however elucidated that at the

beginning when proposed the project provoked some oppositions and protests before it was accepted and embraced. The implementation of the project was complex because the destruction of around 50 houses was necessary to widen the river and create more space for water. A press article (Carlier, 2016) interviewing a couple of people whose house was demolished shows that a compensation allowing them to rebuild another house was given to them after a legal battle. However, after opposing this project at first, residents became aware that the flood damage could be more costly and devastating than relocating. They are also satisfied with the implementation of the project and the new recreational spaces that were provided to them (Carlier, 2016). Not to mention, this remarkable example of water approach innovation attracted people from different parts of the world and contributed to boosting the local economy (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).



Figure 28 Aerial view of Nijmegen. Photo by Irvin van Hermert.

The ‘Wadi’ system, introduced by the Dutch city of Enschede, aiming at capturing, transporting, and storing rainwater to avoid it from being mixed with sewers, is also implemented in new neighborhoods in Nijmegen. This system reduces the risk of flooding in comparison to traditional sewage system. However, the disadvantage of this measure is that it could have high maintenance costs and it is not easily implemented in existing neighborhoods. (Bernhard, et al., 2018). This system is not considered a good solution especially in neighborhoods with high risks in Nijmegen such as the old city center (Bernhard, et al., 2018).

Nijmegen is expanding north of the river as a new district is being developed with 12,000 houses. The expansion of the city towards the northern neighborhood is assured in a sustainable manner based on the 'Ecopolis' approach (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020; Municipality of Nijmegen, 2017). The new district includes energy neutral buildings and houses, and a sustainable transportation system including car-free streets and cycling paths (Verhoeven, 2017). Moreover, green, and blue infrastructure is developed to collect rainwater and use it during dry periods and provides green recreational spaces for citizens.

A Nijmegen climate consultant (interview, 2021) clarified that the municipality developed an environmental vision 'city in motion' assuring the city's expansion in a sustainable manner to accommodate new housings. The vision is to ensure that Nijmegen is a compact, livable city, where people can easily move from one place to another. To achieve this vision, the city chose to go through the procedure of environmental impact assessment; "This shows that the municipality attaches great importance to take into account environmental effects in the integral choices of the environmental vision" (Nijmegen climate consultant, interview, 2021). Nijmegen considers the risks that could arise in the light of urbanization increasing the pressure on the city and impacting the quality of the living environment, to ensure that the city's attractiveness and resilience are not impacted (Nijmegen climate consultant, interview, 2021).

Nijmegen, just like other Dutch cities, has great engineering technologies for water management. Yet, one of the challenges that the city faces is the availability of material resources, such as lands, to implement adaptation projects. As the city is compact and everything is already built-up, it is more challenging to increase the share of green and blue infrastructure necessary to improve the city's adaptability to climate change. This is easier in areas like the north side of the city, where it is not yet completely built up affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). He explained that making the old part of the city (i.e., city center) climate-proof remains a challenge, thus "small scale initiatives such as increasing the share of greenery in the city center and different neighborhoods are suggested as well as the separation of the rainwater drain". He added that people could pitch in their ideas for greening projects at the scale of the neighborhood, these projects are judged and prioritized by the municipality.

The city has more than 300 participation projects and these can be found on an online platform⁴⁰. Moreover, on the municipality's website, a participation map⁴¹ is made available providing an overview of citizen involvement in the implementation of projects in public spaces. These projects include the maintenance of green areas, the vegetation of gardens and urban agriculture, forest and park management, projects to increase the sense of community (i.e., meeting the neighbors) as well as projects of supervision and safety.

The municipality implemented the 'Operatie Steenbreek' (Breaking Stones) campaign which aims at engaging the citizens and encouraging them to replace the pavements and bricks of their properties with gardens and plants (Bernhard, et al., 2018). The Municipality of Nijmegen (2017) stated in its EGC award application that more than 190 000 paving stones were replaced by trees of plants and more than 10,000 trees were planted. The European Commission (2017) in response to Nijmegen's EGC application affirmed that the 'Operatie Steenbreek' project has contributed to making the neighborhoods in the city greener, more attractive, and fresher, in addition to other

⁴⁰ <https://nijmegen.mijnwijkplan.nl>.

⁴¹ <https://www.participatiekaart.nl/nijmegen/>.

initiatives such as the planting of trees in shopping streets and the installation of water fountains around the city. These projects were implemented not only for aesthetic purposes but also because they allow to cool and freshen the city center asserted the municipality of Nijmegen (2017) explaining that they store excess rainwater while exposing citizens to nature and providing them with recreational areas and meeting spaces.

According to the expert panel of the European Green Capital Award (European Commission, 2017), the case of Nijmegen is an example projecting how former brownfields and industrial sites can be transformed into green, diverse, and multifunctional areas presenting a healthy environment to citizens. The municipality invested over 1.4 million euros in the European 'Future Cities' project which helped shape various aspects of the city's climate plan. The "Green Allure" initiative, which was in part made possible due to the 'Future Cities' project, was implemented to convert dull urban landscapes to innovative green areas. As a case in point, a parking space in central Nijmegen was rehabilitated and transformed into 'Korenmarkt Park', an open green public space highlighting some archaeological features.

An environmental researcher at the Radboud University (interview, 2020) asserted that the municipality is publishing budgets regularly and transparently on its website. The municipality of Nijmegen (2017) stated in its EGC application that more than 300 million euros have been allocated, majorly by the national government and partly by the municipality, for the implementation of projects North of the Waal River between 2010 and 2020. Moreover, south of the Waal, 6 million euros are dedicated annually for the management of public green areas. Between 2010 and 2015, around 5 million were dedicated to the planning and the realization of new parks in residential areas. Moreover, between 2008 and 2013, 2.5 million were reserved for the greening of the city center. An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) however clarified that the city has a large budget for the implementation of water management projects but lacks the budget for the development of green infrastructure systems. He affirmed that "the budget that the city has is mostly for the management and maintenance of existing green spaces rather than the development of new ones". Nijmegen also supports citizens by offering loans to incite them to implement adaptation initiatives (Bernhard, et al., 2018). The municipality (2017) affirmed in its EGC application that 100 thousand euros are offered yearly as a subsidy for the investment in green roofs. The city is also providing subsidies for green facades, rainwater barrels, and the separation of rainwater from sewage systems. As a result, various stakeholders including entrepreneurs, city institutions, and residents have contributed to the development of ecological and urban greening projects (Environmental researcher at the Radboud University, interview, 2020).

Nijmegen received the "Green Capital" award for the year 2018, bestowed to reward the city's clear, driven, and convincing vision according to the judges. The General Directorate of the Environment at the European Commission (2018a) avowed in an online publication that the city's policies are exemplar in terms of climate change adaptation, waste and water management, and cycling. In this publication (European Commission, 2018a), the adjoint general director, Joanna Drake, declared that the city's policies, as well as the important participation of its citizens, give the city the position of a "true ambassador of change".

In a public communication by the General Directorate of the Environment at the European Commission (2018a), Hubert Bruls, the city's mayor since 2012, asserted that Nijmegen is working hard to ensure sustainable development as it has the ambition of becoming climate neutral by 2045 and climate-proof by 2050. He added that the municipality sets a large margin of action to ensure a greener, more sustainable, and healthier city. An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) highlighted that the city is increasingly becoming more climate-proof and expects that in the next decade the city would have solved the major issues. He however underlined that more effort and investments are needed to increase the city's resilience to the issue of heat stress.

4.2.5 Monitoring and Evaluation: Annual city and neighborhood monitor tracking the development of neighborhoods and the city

The PBL-Environmental Assessment Agency in the Netherlands is working on the development of a system to monitor adaptation at a national scale through inspecting the various approaches adopted in several cities and countries (Van Minnen et al., 2018).

Annually, the Ministry of Infrastructure and Environment reports the progress to the house of Representatives based on annual monitoring achieved by the Delta Program on Spatial Adaptation. Similarly, all governments are expected to report their progress and results yearly. The Delta program has opted to develop a monitoring and evaluation system to respond to new insights and developments and to accelerate efforts or make any necessary adjustments. The monitoring is crucial to achieving the main goal of the Delta program for spatial adaptation which is ensuring a climate-resilient country by 2050 (Van Minnen et al., 2018).

The 9th Delta program (Ministerie van Infrastructuur en Waterstaat, et al., 2018) clarified that the evaluation process considers whether the implemented measures are on schedule, whether the goals have been achieved, the integrality of the approach, and where necessary if there's a broad stakeholders' participation. As the delta program operates in a dynamic environment, and to keep a balance between quick response and flexibility on one hand, and coherence in choice and sufficient stability, on the other hand, the monitoring is done on an annual and a six-yearly basis. The purpose of the six-yearly review is to check whether the delta decisions and strategies need any adjustments and to make proposals for modification affirmed the 9th delta program (Ministerie van Infrastructuur en Waterstaat, et al., 2018). The latter detailed that the regions must monitor progress on spatial adaptation. It presented the quantitative and qualitative indicators that are determined annually such as the number of kilometers of flood defense as well as the evaluated economic and casualty risks. Other indicators are also considered including the number of water boards, municipalities, and provinces that have conducted a risk dialogue, and have carried out a test for flooding, drought, water safety, and heat stress, have set up a strategy as well as implementation agendas (Ministerie van Infrastructuur en Waterstaat, et al., 2018).

No common monitoring approach is adopted by regional and local levels of government (Klostermann et al., 2015). Van Minnen et al. (2018) explained that most cities are still at an early stage of implementing adaptation strategies and developing monitoring and evaluation systems. An adaptation policy advisor at the municipality of Nijmegen (interview, 2020) added that the monitoring and evaluation of adaptation "is scale and context-specific and deals with great uncertainties". He elaborated that it is relatively complicated for responsible authorities to

evaluate adaptation measures as they are characterized by both short- and long-term time frames. Local governments are likely to face methodological as well as practical challenges given that “unlike mitigation, where the trend in greenhouse gases is a relatively easy-to-measure indicator, there are no off-the-shelf metrics for measuring progress or the success of adaptation” (Van Minnen, et al., 2018).

“As the city of Nijmegen does not have a local adaptation strategy yet, it does not have an index or and indicator particular to monitor climate adaptation” affirmed the adaptation policy advisor at the municipality of Nijmegen (interview, 2020). He however clarified that the city is planning on developing an adaptation strategy by the end of the year 2021 and a monitoring tool will be part of it. He also explained that the office for Research and Statistics at the municipality is using an annual city and neighborhood monitor that provides an image of the state and the development of neighborhoods and the city allowing to inspect and evaluate the efficiency of the measures in place in improving the city’s sustainability and resilience to climate change. This monitor consists of three parts. First, it includes research information and statistics about 35 residential areas in Nijmegen (which are to be updated every 2 years). Second, it presents the distribution of budget. Third, it presents the main tasks to be completed in the administrative period 2018-2022.

The city and neighborhood monitor results are reported and communicated on an online platform⁴² allowing an open public accessibility to monitored data in various themes. The city of Nijmegen compares its results to benchmark cities of comparable size (mid-sized cities) including Arnhem, Tilburg, Maastricht, Leiden, Groningen, Enschede and Eindhoven. It looks at various programs including administration and organization, population, cultural heritage, economy and tourism, education, accessibility, public space, safety, sport, work and income, housing, and urban development as well as the welfare, neighborhood development and healthcare. Nijmegen dedicates a special focus to the social aspect, the attractiveness of the city, its sustainability and economic resilience (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).

In the social area, it assesses the health and well-being of youth and adults, the care and support provided as well as the income and the affordability of health services. In the field of sustainability, the city has quantitative and qualitative indicators to evaluate energy consumption, sustainable mobility, the consumption of raw materials (e.g., recycling percentage, amount of residual waste) as well as environmental qualities (e.g., satisfaction with the green areas, noise pollution, etc.).

To assess the attractiveness of the city, the satisfaction as well as the issues that are faced on daily basis by residents are considered. The city also considers the opinion of visitors and entrepreneurs in the city as well as the image of the city among Dutch people (Municipality of Nijmegen, n.d.).

Furthermore, to evaluate the economic resilience of the city, the neighborhood monitor looks at the evolution in the number of jobs across all sectors, unemployment rates, as well as entrepreneurial opportunities.

Some of the indicators presented in the city and neighborhood monitor allow the municipality to understand its performance in adapting the city to climate change and increasing urban

⁴² <https://swm.nijmegen.nl>.

resilience affirmed an adaptation policy advisor at the municipality of Nijmegen (interview, 2020). He clarified that the city relies mainly on local data for monitoring and evaluation, residents are asked to provide their comments on various themes, including sustainability related topics. A climate adaptation strategist at the province of Gelderland (interview, 2020) added that the municipality also takes benefits from data available at a regional and national level, as well as data provided by research institutes.

4.2.6 Understanding Success and Limiting Factors: Increased actors' engagement confronted by the challenge to appeal to underprivileged groups

In the Netherlands, more consideration is given to creating links between climate adaptation measures and other tasks at an urban scale. Linking is one of the topics during the risk dialogue, where not only is spatial adaptation discussed, but also about the connection with other social tasks at street, neighborhood, and area level. This linking offers various opportunities and accelerates the implementation of adaptation measures as it increases the acceptability of the projects and creates financial benefits affirmed the Dutch ministry of infrastructure and water management (2019) in its spatial adaptation report.

The objectives, achievements, and future goals of Nijmegen are highlighted in the 'Urban Environment Good Practice and Benchmarking Report for the 2018 award cycle'.

The application for the EGC2018 permitted the municipality to understand levers and limitations to climate governance which underlines the importance of applying to labels or awards and organizing environmental events. "The commitment to the award in itself has been a great lever as it resulted in a series of positive outcomes" affirmed an environmental researcher at the Radboud University (interview, 2020). He evoked that the event allowed fostering environmental and climate policies asserting that "it increased cooperation, communication and the involvement of various stakeholders". The municipality of Nijmegen (2017) confirmed in its application to the EGC award, that joining this initiative has raised reflections on how to actively represent different parts of society and how to increase the involvement of organizations, residents, professionals, volunteers, and students.

However, an adaptation policy advisor at the municipality (interview, 2020) explained that the events conducted in Nijmegen in the light of the EGC application showed that despite great efforts to involve all residents, it remains a challenge to reach out to individuals and groups who are not directly spurred by sustainability. It is also challenging to reach out to underprivileged and lower-income groups, because climate adaptation could require personal dedication or investments, resulting in additional expenses, added an environmental researcher at the Radboud University (interview, 2020). He asserted, "given that Nijmegen is an attractive student city, many graduates tend to stay in it, and some do not find jobs, which increases the number of underprivileged groups".

Different approaches are investigated to reach out to these groups, the municipality of Nijmegen (2017) affirmed in its EGC application that it has "concluded that resident-initiated challenges were best able to reach these groups".

Success and limiting factors for the development of the 'Room for the Waal' projects have been understood. The European Environment Agency (2014), on its Climate Adapt online platform

presenting the 'Room for the river Waal' case study, stated that the development of a series of measures at different locations facilitated the implementation of the project. The financial and technical support provided by the national government was also a major success factor, as the project required huge investments amounting up to hundreds of millions of euros explained an adaptation policy advisor at the municipality of Nijmegen (2020) in an interview. He elaborated that the coordination of efforts and the engagement of various stakeholders including waterboards, municipalities, provinces, and the national government has been crucial. The EEA (2014) in its room for the Waal case study affirmed that the involvement of the local community has also increased the acceptability of the project. However, it clarified that the expropriation of land and the development of compensation schemes was a great challenge. Moreover, despite national support, the budget constraint, and the need to secure funding from municipalities, water boards, and the provinces was at some point a limiting factor.

The adaptation policy advisor at the municipality of Nijmegen (interview, 2020) highlighted that the political environment of the city is a great success factor as local authorities are interested in addressing the issue of climate change and doing efforts to ensure ecological transition as well as climate mitigation and adaptation. He explained that there is a stable political climate at the municipality and that adaptation commitments are not affected by the elections as the political parties with a large majority are in favor of sustainable development and climate action. "The municipal organization allowed the city to succeed in addressing environmental issues as for the past decade, it embraced an integral approach and departments were no longer working in silos" added the policy advisor. He also explained that Nijmegen, being a mid-sized city, also ensured smaller lines of communications between the municipal organization and civil servant stakeholders. Yet, indicated that the scale of the city could present certain challenges as, for instance, "in the municipality of Nijmegen there are 2 policymakers on the team and the engineering office has 20 or 25 engineers instead of 500-600 as it is the case in big Dutch cities like Amsterdam or Rotterdam" (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).

4.2.7 Improving the Governance System in Place: Simplifying procedures and developing a "2050 climate proof" ambition

On the 1st of July 2015, a large majority of the Dutch House of Representatives approved a new environmental Act (Omgevingswet). With the new law entering into force in 2021, the government of the Netherlands (2018) affirmed on its online platform that it aims at improving the coordination between the various plans for spatial planning, nature, and the environment. It also wants to stimulate the development of sustainable projects and give the provinces and municipalities the room to adjust their environmental policies to their objectives and needs affirmed. The new act offers room for general rules instead of detailed permits which allow for the development of innovative approaches and initiatives. It simplifies the development and implementation of projects and reduces the cost and time as the existing environmental law consists of numerous regulations and requirements making it too complicated for people to work with (Government of the Netherlands, 2018).

In 2017 the Delta decision on spatial adaptation was reviewed which led to the conclusion that there is a need to intensify and accelerate spatial adaptation. Consequently, short-term targets to be implemented between 2020 and 2050 have been investigated. To limit the risk of additional casualties and damages, “climate adaptation must become 'the new normal' for developments in the spatial domain so that the Netherlands will be as climate-proof and water-robust as possible in 2050...” affirmed the Dutch ministry of infrastructure and water management (2019) in its spatial adaptation report. The review also examined the relationship between adaptation, ecological and energy transition, and biodiversity to create stronger links between various tasks.

The Ministry of Infrastructure and Water management asserted (2019) in its report on climate adaptation that it made more money available, amounting to € 20 million for 2019 and 2020, to stimulate and facilitate climate adaptation. It elaborated that the amendments to the water act are being worked on to make contributions from the Delta Fund to decentralized authorities to address the issue of flooding. These amendments are set to come into effect at the beginning of 2021 clarifying the conditions under which local and regional governments are eligible for financial contributions.

In the Netherlands, regions play a central role in the development of contingency plans. 25 safety regions are defined, developing each management plans to respond to disasters. In the case of trans-regional incidents, coordination is assured with the state for a national response confirmed the Veiligheidsregio Gelderland-Zuid (VRGZ) on its online platform. The VRGZ is an organization for the preparation and coordination in the field of crisis and disaster management, it includes fire services, medical assistance as well as operational management. It works closely with different partners including the province, the municipalities within (comprising the municipality of Nijmegen), the waterboards, police, and defense as well as healthcare institutions in the region. In preparedness, disaster and crisis response plans are drawn up for the Gelderland-Zuid region, addressing calamities at industrial establishments, floods as well as long-term outages of utilities such as water, gas, electricity, and the telephone.

The flood caused by heavy precipitation in May 2018 in the Netherlands offered new insights affirmed the Dutch ministry of infrastructure and water management (2019) in its spatial adaptation report. Thus, it is working on the development of preventative measures to be taken to reduce the impact of rainfalls on traffic. Moreover, the concerned ministry is developing and implementing emergency measures (e.g., extra pumps) to address the issue of prolonged summer drought which resulted in very low water levels. In the conducted interviews, the adaptation policy advisor at the municipality of Nijmegen and the environmental research at the Radboud University supposed that the city of Nijmegen is prepared to deal with unexpected environmental crises. Various past events proved the willingness and the readiness of the mayor to take immediate action (environmental research at the Radboud University, interview, 2020). Not to mention, emergency services are aware and receive training to deal with different kinds of threats including floods and heavy storms. It is however important to underline that the occurrence of heatwaves is not yet an accepted threat that is totally implemented in security plans (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).

The city views itself as a leader in urban experimentation in the area of sustainable development. The municipality (2017) stated in its European Green Capital (EGC) award application that “Nijmegen is a preeminent urban lab for sustainability, full of expertise and inspiration among residents, companies, and institutes”. It explained that it has addressed and solved various ecological problems that surfaced throughout the years. It also elaborated that it is actively working to ensure energy neutrality and increase the resilience of the territory to various events to ensure the provision of a healthy and sustainable living environment. The municipality of Nijmegen (2017) affirmed in its EGC application that it is aiming on expanding its network and knowledge through continuing to organize conferences and events. Moreover, it is aiming at developing clear goals and execution programs. Not to mention, the initiatives that have proven to be efficient and successful such as ‘Operatie Steenbreek’ (or breaking stones) are to be further expanded and scaled up (Municipality of Nijmegen, 2017).

The city of Nijmegen has the ambition to undergo major transitions in various areas of sustainability in the coming decade. “These transitions will have a massive impact and can only be realized through the participative and integrated manner with which Nijmegen has successfully employed in the last decade” affirmed the European Commission (2017) in its evaluation of Nijmegen’s application to the EGC. The municipality of Nijmegen (2019b) asserted in its EGC2018 technical report that it is aware that sustainable mobility and energy transition are already on the transition path, yet “more focus needs to be given to ensuring a climate-adaptive city”. The city hasn’t drawn up an isolated climate adaptation strategy but incorporates adaptive strategies into existing policy plans as it has been adapting its territory to extreme natural events for a long time. A local adaptation plan for all the parts of Nijmegen is to be developed by the end of 2021 (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). In addition, the municipality intends to implement concrete measures to limit the damages resulting from extreme weather conditions and precipitations (Bernhard, et al., 2018).

The municipality of Nijmegen (2017) affirmed in its EGC application that it has implemented the Delta program, which inflicts increasing resilience to various climate events by 2050. The municipality thus aligns actions and projects at a local scale with the spatial adaptation delta decisions which consists of concrete recommendations and measures for cities. The local government also stated in its EGC application its ambition to make the city climate-proof by 2050 and affirmed that will continue promoting best practices and providing subsidies for green walls and roofs to create a healthy and pleasant living environment.

The European Commission's (2017) evaluation report on Nijmegen’s application to the EGC award asserted that over two-third of the city’s rainwater is discharged through the city’s sewerage system. This reality is met by the municipality’s ambition to completely want to disconnect the rainwater discharge from the sewerage to feed existing surface waters and reduce the need for water treatment (European Commission, 2017).

The municipality (2017) clarified in its EGC application that it has developed a long-term sustainable development vision. It has set itself the ambition of being energy-neutral by 2045 by providing buildings with a sustainable supply of energy and heat. The transition aims at connecting the houses that are at the present being heated by natural gas to sustainable energy resources. To

achieve this goal, a roadmap directed by step-by-step actions is drawn up in the context of the “Power2Nijmegen” initiative.

The Dutch city is also aiming at increasing its bicycle network connectivity by 20% between 2017 and 2027 and improving the existing infrastructure for walking and cycling by increasing linkages to the blue and green infrastructure inside and outside the city confirmed an adaptation policy advisor at the municipality of Nijmegen (2020) in an interview. He asserted that “the city’s policy will focus on behavioral changes” and affirmed that the municipality understands the importance of developing green and healthy cities in which citizens are invited to be active, cycle, and walk. Lastly, the municipality of Nijmegen (2017) presented to the European Commission in its EGC application that it is aiming on developing a full circular economy by 2050 with an intermediate goal to accomplish half of this ambition by 2030. The region ‘Arnhem-Nijmegen’ and the municipality of Nijmegen has the determination to assist industries and entrepreneurs as well as customers in this transition by encouraging and favoring a circular approach. The city’s long-term ambition to reduce its waste production, energy emissions, and become more sustainable, aligns and feeds into its ambition to increase its adaptability to climate events, concluded the adaptation policy advisor at the municipality of Nijmegen (interview, 2020), affirming that “on the long-run, climate adaptation and sustainable development intersect”.

4.2.8 Assessing the Urban Climate Adaptation Governance of Nijmegen

The collected data for the case of Nijmegen presented in the sections above (sections 4.2.1 – 4.2.7), through the review of various documents and the conduction of interviews with various key actors, allowed to answer the set of 50 close-ended questions that were presented in the methodology (section 3.6.1) forming the climate adaptation governance index.

The application of the developed index to the city of Nijmegen has shown that it has a favorable climate adaptation governance with a value of 8.6/10 (*refer to appendix III – table 13*). This means that local government is addressing the issue of climate change through the development of corresponding strategies and the implementation of appropriate measures based on an exhaustive understanding of local climate impacts and vulnerabilities. Nonetheless, even a city like Nijmegen, with a favorable adaptation governance approach could still be vulnerable to climate impacts given that adaptation is a process that needs to be continuously improved based on insights and experience.

The visualization of the results displayed in the figure below (*figure 29*) presents an overview of the city’s index score in various areas of climate governance (as introduced in the conceptual model – section 3.4).

The results (*detailed in appendix III – table 13*) show that Nijmegen has a good performance in various areas of governance of climate adaptation. The city has a great understanding of the impacts of climate change and its ramifications on various sectors, which is contributing largely to improving the adaptation governance response. This understanding is accentuated due to the development of local vulnerability maps and the city’s collaboration with the local university to produce knowledge at a local scale. However, this does not mean that the city should stop investing in this area of climate governance as things evolve and new knowledge needs to be produced in response to the evolution of events. The city is invested in the development of

adaptation measures and has worked in collaboration with the province of Gelderland to set up a local adaptation strategy, which explains its good performance in the area of ‘developing adaptation strategies’. The development of a local adaptation plan at the scale of the city could improve the Nijmegen’s governance approach to adaptation.

The results indicate that the city is working on implicating and mobilizing actors through ensuring a participative governance approach, yet more effort is required at this front. In this case, behavioral and cultural change seem necessary to improve the city’s adaptive capacity and increase its urban resilience. The visualization of the index score shows that the implementation of various measures has contributed to boosting the city’s adaptive capacity and climate resilience. However, the multiplication of successful initiatives coupled with the dedication of a larger budget to the development of green infrastructure systems could further improve local adaptation governance efforts. The existence of an annual ‘city and neighborhood monitor’, providing an image of the state and evaluating the measures in place in improving the city’s sustainability, has contributed to improving the city’s performance in the area of ‘monitoring and evaluation’. This nonetheless underlines the need for developing qualitative and quantitative indicators particular to assess climate adaptation efforts at a local scale. Key local actors are aware of the success and limiting factors to the governance of climate adaptation at a local scale, however, continuous efforts are needed to allow for improving the governance system in place and increasing urban resilience.

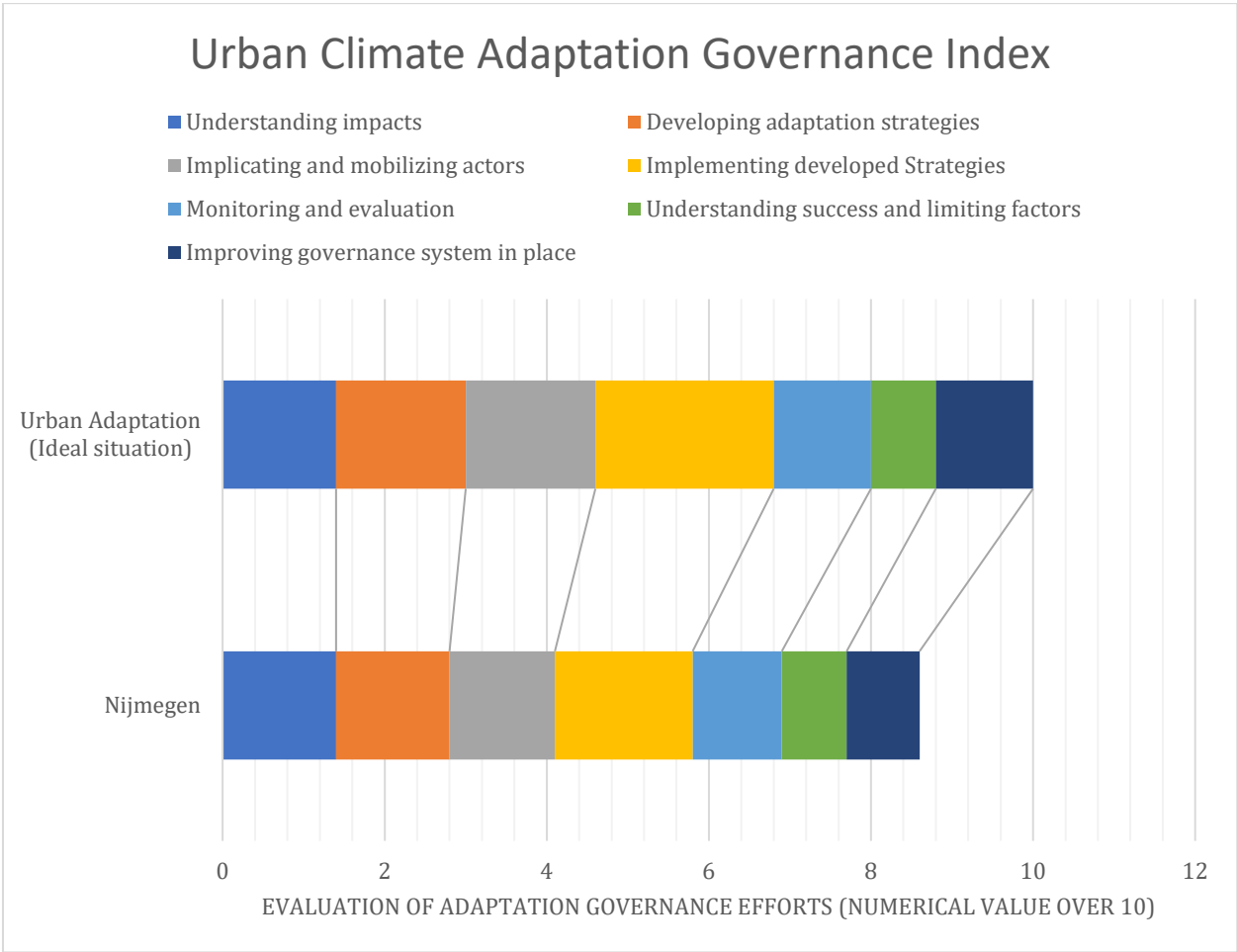


Figure 29 Visualization of the index score of the City of Nijmegen across various areas of climate adaptation governance.

4.3 The case of Leuven, Belgium



Figure 30 The city of Leuven. Source: Google Maps, 2021.

The case of Leuven is examined to develop a better understanding of climate governance in a mid-sized European city in Belgium, a European country embracing a federal system.

To assure data collection published literature was reviewed including documents and articles developed by federal and local environmental agencies, national and international adaptation platforms as well as experts in the field. Environmental and climate policies, as well as territorial plans developed by the Flemish government and the municipality of Leuven, were also examined. Lastly, articles and documents published by the local press, Leuven 2030 initiative, and the city's official website were reviewed. For this case, and due to Covid19 travel restrictions imposed in 2020 and 2021, a field visit was not possible. To complete data collection, online interviews were conducted with different actors including an associate at the Flemish Environment Agency (2021), a municipal councilor representing the Green party and an Effective member of the committee on mobility, climate and sustainability, agriculture, and consumption (2020) and an Alderman in the board of mayor (2020). An interview was also conducted with an environmentalist and researcher at the KU Leuven (2021). A synthesis of the data collected for the case of Leuven is presented below and structured following the 7 areas of focus in the governance of climate adaptation (introduced in the developed conceptual model - Section 3.4).

Leuven is a medium-sized city in Belgium, a federal state composed of three regions (the Walloon, Brussels-Capital, and the Flemish Region) and three communities (French, German, and Flemish-speaking community) (figure 31). The selected case study covering the area of 57 km² is the capital of the Flemish Brabant province and is geographically located in the center of the country, 25 km away from Brussels, the capital of the country (Heyvaert, & Jansen, 2018).

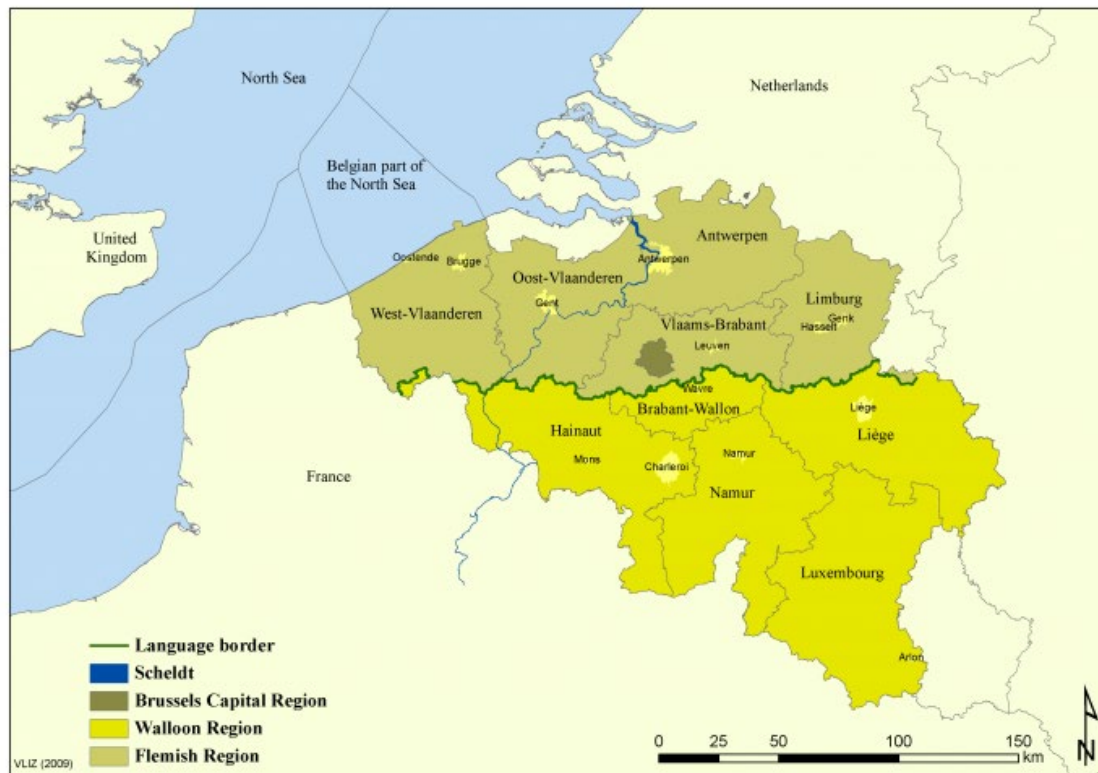


Figure 31 An administrative map of Belgium which is composed of 3 independent regions: Flanders, Wallonia, and Brussels. Source: VLIZ, 2009.

The Dijle River flows through Leuven which is home to more than 102,300 inhabitants (Statbel, 2020). The city attracts students, scientists, and researchers as well as tourists who are interested in art and heritage as the city has a rich history and cultural heritage and hosts one of Europe's oldest universities, the Catholic University (KU) of Leuven. Leuven's economy is majorly based on knowledge production as well as trade and services. The city's attractiveness and its strategic location have led to rapid population growth over the past decade. The situation suggests that this trend will continue for a while which presents both challenges and opportunities in terms of sustainable urban development (Heyvaert, & Jansen, 2018; La Rivière, 2015).

As identified by the Köppen climate classification, Belgium has an oceanic climate (Cfb), with cool summers and moderate winters. As the country is small, there are little differences in weather conditions from one region to another, however, the marine influence is less marked in Leuven as it is not a coastal city.

According to the European Environment Agency's (2017) classification of impacts of climate change on Europe, Leuven is situated in the Atlantic region which is likely to be impacted by climate change and witness an intensification of winter precipitation, a rise in river flow, and an increased risk of river flooding.

4.3.1 Understanding Impacts and Vulnerabilities: More knowledge at a regional level, less at a local scale

The national adaptation strategy (NAS) developed by the Belgian National Climate Commission. (2010) presented the impacts of climate change on Belgium and its ramifications on various sectors

including agriculture, forestry, health, biodiversity, ecosystems and water, tourism, coastal areas, physical infrastructure, and production systems.

Belgium's seventh national communication and third biennial report on climate change (Belgian National Climate Commission, 2017) underlined that the effects of climate change have already been felt at a national level as the country has witnessed an increase in temperature of + 2.4 °C in comparison to pre-industrial levels as well as an increase in the yearly precipitation average. Not to mention, the number of days marked with heavy precipitation is rising which increases flood risks.

Climate Projections at the scale of the country -on the horizons 2030, 2050 and 2085- predict hotter winters and summers over the coming 80-100 years as average temperatures could increase between +1°C and +4.6 °C in winter (depending on the considered scenario), and between 1.1 °C and 7 °C in summer. Summer precipitations could decrease by -53% before 2100, meanwhile winter precipitations are likely to increase by +36% during the same timeframe. The Belgian National Climate Commission (2017) highlighted that the alteration in temperatures and precipitations would have minor differences within Belgium yet underlined that densely populated cities are expected to deal with higher temperatures than peri-urban or rural contexts due to the UHI effect. Additionally, there's an increased risk of serious water shortages which could have further consequences on navigation, conflicts of usage and water quality.

The country's 7th national communication report (Belgian National Climate Commission, 2017) stated that vulnerability, impact, and adaptation assessments have been supported and conducted at both federal and regional levels. It also affirmed that primary and sectorial studies were considered a first step towards developing federal and regional adaptation plans. Nonetheless, the report underlined that despite efforts to understand the costs of the lack of adaptation, there is no clear identification of economic impacts of climate change given that it is challenging to adopt global models, employed to estimate the costs of adaptation, at a local scale (Belgian National Climate Commission, 2017).

The first Flemish Climate Policy Plan (VKP) (2002-2005) introduced the impact of climate change on natural systems and on society both at a global and regional scale. A second VKP (2006-2012) reinstated and emphasized the importance of mitigating climate change. An updated VKP (2013-2020) presented different climate scenarios and shed the light on recent observations as well as the impacts of climate change on various sectors. It also included a section on adaptation constituting the Flemish Adaptation Plan (VAP). The VAP (2013-2020) developed by the cabinet of Joke Schauvliege, the Flemish Minister of Environment, Nature and Agriculture, affirmed that, in the Flanders, climate change increases the risk of river floods, coastal floods as well as pluvial floods due to the saturation of sewage systems which could have negative effects on water quality. It underlined that agriculture is likely to be negatively impacted due to the deterioration of water quality, damage caused by extreme weather conditions, infestation, and diseases. It also asserted that climate change increases the frequency of forest fires and could have negative impacts on biodiversity and the natural environment in the region. The VAP (2013-2020) stated that industries and services could be negatively impacted especially due to the ramifications of flooding or water shortages on commercial activities. It affirmed that climate change impacts mobility as flooding could perturb transportation systems and waterways could be closed in cases of extreme droughts. It also explained that energy demands are affected as during the summer period, the

need for cooling is likely to increase, while during milder winters the demand for heating could decrease. The Flemish climate plan (2013-2020) asserted that climate change could affect the built environment, as for instance heavy rainfalls could lead to the destruction of some constructions and the level of discomfort of city dwellers could increase. It also mentioned that changes of climate conditions could lead to the spread of viruses or diseases and lead to serious health impacts. The Flemish climate plan did not neglect the fact that changes in weather conditions could have some positive impacts on biodiversity and on industries as new production or service opportunities could arise. For instance, the alteration of climate conditions could have a positive effect on tourism in Flanders as the season attracting tourists could be lengthier.

In 2015 the Flemish Environment Agency (VMM) issued the 'MIRA Climate Report 2015: About observed and future climate changes in Flanders and Belgium'. Moreover, the VMM updates information about the evolution of climate conditions in Flanders on a yearly basis and shares it on the Flanders' online climate portal⁴³ to inform the public about the impacts of climate change on the region.

The Flemish Environmental MIRA report (Brouwers et al., 2015) presented the observed climate changes (e.g., changes in temperatures, in precipitation patterns etc.) as well as climate projections over 30, 50 and 100 years based on 3 scenarios in terms of impact: Low, medium, and high. It indicated that, in Flanders, considering a high impact climate scenario, annual average temperatures are likely to increase from 0.7 to 7.2 °C in the coming century. According to the report, the increase of average temperatures is greater in the summer period than in the winter period. Also, an increase in the average number of extremely hot days, particularly in the center of Belgium (where Leuven is located), is predicted (Brouwers et al, 2015). Additionally, the intensification of heat stress in urban areas is projected, due to the anticipated expansion of existing cities. Considering a high impact scenario, in the coming 100 years, wet days are expected to increase by 8% in winter and 4% in summer, while dry days are expected to augment by 42% in winter and 90% in summer (Brouwers et al., 2015).

The Belgian National Climate Commission (2017) presented in a national communication report that the science and innovation policy in Flanders supports research and advances from a bottom-up perspective as most climate research takes place in research institutes and universities. Various local research centers conduct studies to improve the knowledge and understanding on matters related to climate change affirmed an associate at the Flemish Environment Agency (interview, 2021). For instance, the Flemish Institute for Technological Research focuses on inventive technology supporting the transition to a more sustainable production. In addition, some sector-specific reports on adaptation are developed such as the research conducted on behalf of the Department of Agriculture and Fisheries 'Adaptation options of the Flemish agriculture to climate change'. Additionally, the Belgian Federal Science Policy Office (BELSPO) financed adaptation-related research projects in various sectors. In 2014, BELSPO included adaptation as a priority theme in its call for project proposals to improve the comprehension of the impacts of climate change on various sectors and increase knowledge of adaptation as well as the development of related policies.

In 2014, a federal government pact endorsed an open data policy with improved access to public data. The data is made available to be re-used by researchers, citizens, governments, and

⁴³ <https://klimaat.vmm.be>.

companies to ensure a community built around the use of information to ensure improved development and innovation (Associate at the Flemish Environment Agency, interview, 2021).

The municipality of Leuven and the non-profit organization 'Leuven 2030' (addressing environmental and climate issues) work closely with KU Leuven (Environmentalist and researcher at the KU Leuven, interview, 2021). The knowledge produced at KU Leuven is used to inform the development of local climate policies affirmed a Leuven municipal councilor representing the Green party (interview, 2020). More concretely, in 2013, KU Leuven presented a scientific report (Vandevyvere et al., 2013) which includes an overview of possible scenarios for achieving a climate-neutral city by 2050. The report defined the sectors with high CO₂ emissions, impacting climate change, however, it did not identify the sectors affected by this global issue. Yet, the development of this report was a steppingstone as it provided climate knowledge at the scale of the city of Leuven and proposed corresponding measures (Vandevyvere et al., 2013).

"The fact that there is a direct collaboration between the municipality and the local university [KU Leuven] is fundamental and assures the availability of climate-related knowledge at a local scale" asserted an alderman in the board of mayor in Leuven (interview, 2020).

The Belgian National Climate Commission (2017) presented in the 7th national communication report that a public survey was conducted in 2017 by the federal climate change service showing that Belgians are aware of the importance of tackling climate change as 85% of the people acknowledged that the problem needs to be addressed urgently.

A press article (Renier & Van den Eede, 2019) asserted that in Leuven, more than 10,000 protestors hit the streets of the city on the 7th of February 2019 demanding politicians to address climate issues and take action in the light of the climate demonstrations which were held in more than 100 countries. Schools in the city cooperated by giving their students some time off. In this article (Renier & Van den Eede, 2019) the Mayor Mohamed Ridouani stated that it was the largest demonstration passing through Leuven and that he is Proud of the Youth Commitment. He also highlighted that the city is working on the project Leuven 2030 and wants to do even better.

The Leuven 2030 organization plays an important role in developing public communications, raising awareness, and working on inspiring key workers at the city, organizations, the university, and local citizens to do the necessary efforts to tackle climate change affirmed an alderman in the board of mayor at the city of Leuven (interview, 2020). He elucidated that "in the city's election in 2018, climate change concerns were determinative, and this shows that most citizens in Leuven are aware of the importance of addressing this global issue."

Heatwaves and Urban Heat Island Effect

Belgium's seventh national communication and third biennial report on climate change (Belgian National Climate Commission, 2017) stated that in Flanders, the number of heatwaves has shown not a uniform but an increasing trend since the 1970s. It presented that, the length of heatwaves changed from 5 days per year on average at the beginning of the 20th Century, to 11 days per year from 1988 until 2016. The number of extremely hot days with a daily average temperature exceeding 25 °C is expected to increase from just a few days per year to 74 days per year by 2100. The number of extremely cold days (daily average temperature < 0 °C) could fall back to 0 per year (Belgian National Climate Commission, 2017).

The Flemish Environment Agency (VMM) underlined on its online climate portal⁴⁴ the urgency of the matter by giving the example of Belgium which has already experienced the consequences of the 2003 heatwave by recording 2000 casualties. It asserted that urban climate hotspots, including Leuven, are expected to feel stronger climate effects in comparison to rural areas. It elaborated that heat stress due to rising temperatures is mainly sensed in densely built environments, explaining that the urbanization of the landscape causes an alteration to the local climate as various materials used in the urban infrastructure (e.g., asphalt and concrete) capture the heat. As presented on the Flemish climate portal, the temperature difference between a city and its rural environment rises to a few degrees, sometimes even with peaks of 7 to 8 ° C and more, especially at night. Consequently, heatwaves occur more frequently and more intensely in urban environments. The VMM elucidated on its online platform that in winter, this could have some advantages as it could reduce mortalities in cities due to a decreased exposure to cold and low temperatures. However, it warned that the UHI effect is accentuated during heatwaves leading to severe consequences such as mortality, especially among children under 4 years old and elderly over 65 years old.

To improve the understanding and knowledge related to this topic, a mapping of UHI has been conducted at the scale of the Flemish region and is publicly available in the form of an interactive map available on the region's climate portal developed by the VMM. The interactive map allows to zoom in and get a better understanding of the situation at the scale of various territories in Flanders.

As presented in the city's 2025|2035|2050's roadmap (De Paep, Verachtert & Van Reeth, 2019), between 2010 and 2016, the number of heatwave days was 5 to 20 times higher in Leuven than in rural areas. The roadmap elucidated that more intense and longer heat waves are not only unpleasant for city dwellers, but they also cause an alarming increase in mortality rates, reduced work performance, and increased energy consumption for cooling.

Heavy Storms and Flooding

Various environmental weather extremes and disasters have been recorded in Belgium since 1992, affirmed the Belgian National Climate Commission (2017) in a communication report. It presented the example of the 2002 floods and storms which have devastated the country as this unfortunate event produced a ratio of 23.3 victims per 100 000 inhabitants. According to the report, the number of affected people, as well as deaths recorded due to natural disasters in the country, exhibits a variable trend mostly due to the inconsistent and unpredictable nature of natural and environmental disasters. The report informs that in Belgium the number of days with heavy precipitation has increased; in the mid-1900s there were only 3 days of heavy precipitation per year in comparison to 5 days today.

The Flemish Environmental Reporting Service (MIRA) report underlined that in Flanders the sector that will be mostly influenced by climate change is water management (Brouwers et al., 2015). The Flemish Environment Agency (VMM) (2019), in its drought and flooding action plan, informed that the region has experienced major floods in the past, such as the floods of 1952 and 1975. The situation thus urged the Flemish government to act on the matter by raising the number of dikes

⁴⁴ <https://klimaat.vmm.be/nl>

along the coast, providing mobile barriers, and adding sand replenishment along the coast. The VMM (2019) however asserted that infrastructure systems alone will not protect the territory against every flood and that there's a need to prevent damage from flooding through the elaboration of a multi-layered approach including the prevention of climate change, the protection of the territory as well as the development and the implementation preparedness measures. The Flemish drought and flooding action plan (VMM, 2019) detailed that winter days in the regions are expected to become wetter, higher peak discharges leading to flooding from watercourses are anticipated and the risk of river flooding is to become 10 times more likely. "This means that areas that are currently flooded once every 100 years can flood once every ten years, and areas that already witness floods once every ten years are likely to be flooded every year" (VMM, 2019). Not to mention, flood levels are expected to rise by approximately 20 cm on average. The situation is alarming as flooding and waterlogging could cause severe damages to the built infrastructure. Also, flood risks are not only limited to winter. Even though summer is getting drier, rainy summer days could expect more intense precipitation which could cause severe flooding as well as damages (VMM, 2019).

The Flemish Environment Agency (VMM) asserted on its online climate portal that large river valleys are likely to deal with flooding more often. Strongly inclined upstream valleys and dense urban drainage systems are the most sensitive. According to the Flemish drought and flooding action plan (VMM, 2019), the Coordination Committee on Integrated Water Policy developed a preliminary flood risk assessment in the implementation of the European Flood Directive as the territory is subject to significant flood risks. The risk assessments elaborate on economic, social, cultural, and ecological damages in the case of floods due to coastal, pluvial, or fluvial water origin and include long-term evolutions such as climate change.

Flooding is not new to the city of Leuven, as the area has experienced numerous floods throughout history, such as the floods of 1980, 1981, 1982, and 1996 (La Rivière, 2015).

These inundations occurred following heavy rainfalls or after heavy melting of ice succeeding cold winters, resulting in the overflowing of the river. In 1891, the city witnessed the heaviest flood (*figure 32*), as recorded in historic documents, which led to the inundation of the whole lower city and disastrous consequences (La Rivière, 2015). Terrens, Haesevoets, & Nuts (2011) stated that the Leuven flood of 1981 led to overall economic damage of 395 million euros and asserted that if a similar flood were to occur now, the cost of damage could exceed this number. Another devastating flood occurred in 1906, nonetheless, unlike the 1891 flood which occurred due to the overflowing of the Dijle, it was the result of heavy rainfall which couldn't be processed by the existing sewage system (La Rivière, 2015).

Upstream of Leuven, the river Dijle passes through agricultural and underdeveloped lands, once entering the city, the river is restrained by urban developments (Terrens, Haesevoets, & Nuyts, 2011). As rainfalls are expected to increase in frequency and intensity in the light of climate change, managing floods and containing river levels will be a great challenge, asserted the city of Leuven (2017) in its application for the European Green Leaf award. The Leuven 2030 roadmap (De Paep, Verachtert, & Van Reeth, 2019) declared that the occurrence of floods could increase in the coming decades by a factor of 10.

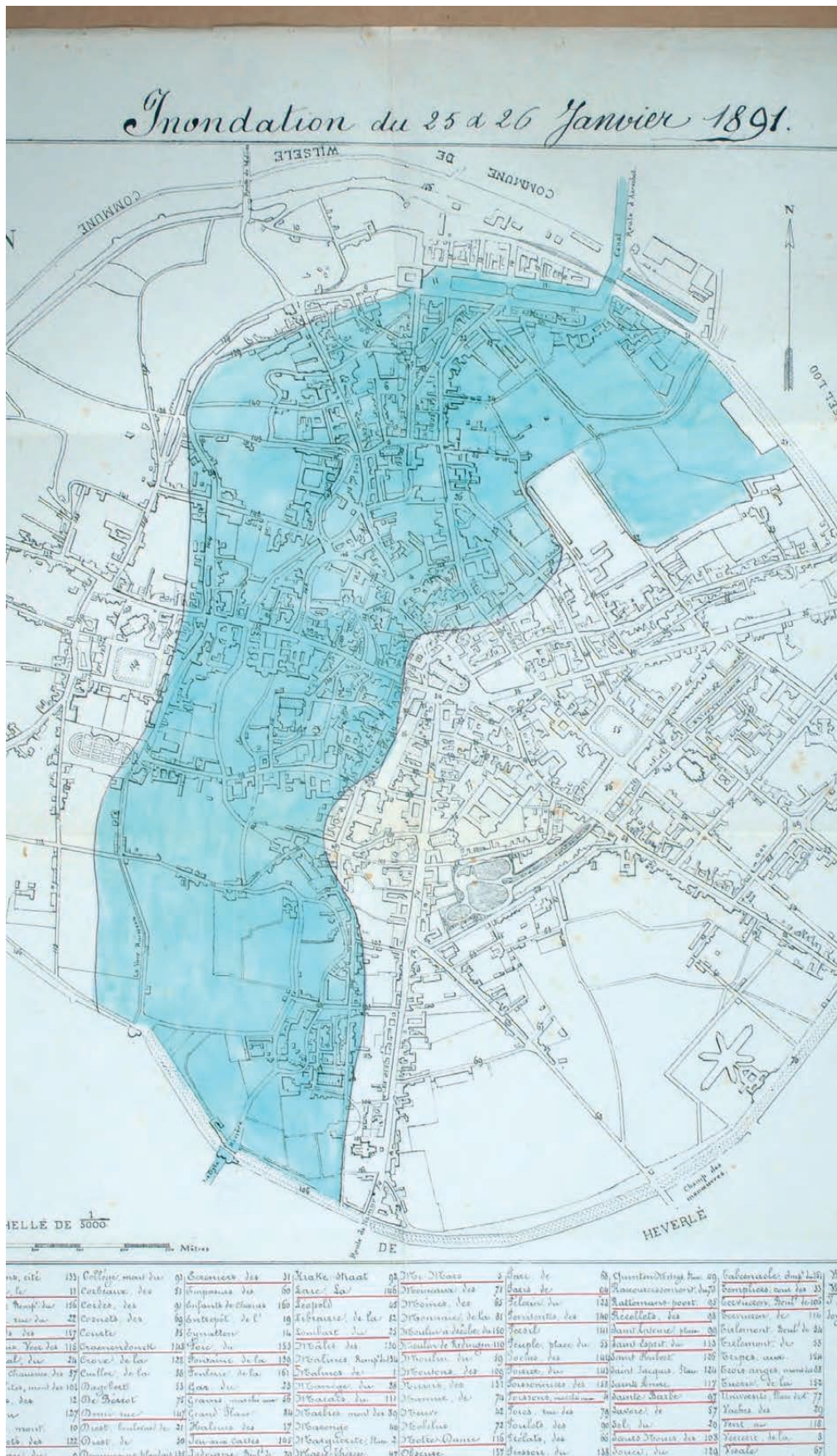


Figure 32 The Leuven inundation of 25 & 26 January 1891. Source: La Rivière, 2015.

Droughts and Reduced Water Availability

The Flemish Environment Agency (VMM) (2019) informed in its drought and flooding action plan that the region is extremely vulnerable to water scarcity. It clarified that Flanders has one of the lowest water availabilities per inhabitant due to a combination of a high population density and a relatively limited presence of surface and groundwater. The VMM (2019) also affirmed that large quantities of water are being extracted from surface and underground water for industrial, agricultural, and domestic usage.

The river basin management plan (2016-2021) indicated that some groundwater containers present an insufficient quantitative state due to the imbalance between pumping up groundwater and replenishing it. In 1976, 2011, 2017, and 2018, the Flemish region was confronted with extreme drought (Heyvaert & Jansen, 2018). Climate projections demonstrate that the frequency and the intensity of extreme drought are likely to increase in Flanders in the future. Therefore, further attention needs to be paid particularly to the effects of climate change on droughts given that it could lead to considerable economic consequences (Heyvaert & Jansen, 2018).

Climate projections predict that the volume of precipitation could decrease by 52% on the horizon 2100 and the number of days without precipitation is expected to increase sharply. Accordingly, the number of dry days can increase from 173 now to 236 dry days in 2100 under the high impact scenario (Heyvaert & Jansen, 2018).

On its online climate platform, the Flemish Environment Agency (n.d.) stated that due to higher temperatures, less summer precipitation, and higher evaporation rates, the cumulative precipitation deficit is expected to increase particularly between April and September. It declared that the average precipitation deficit in a year could rise to 485 mm by 2100. It clarified that such extreme drought could last 4 times longer than the extreme drought of 1976 and 2018 and could occur more frequently (once every 4 to 5 years on average). The situation has harmful social, economic, and environmental consequences.

The Flemish adaptation plan (VAP 2013-2020) developed by the cabinet of the Flemish Minister of Environment, Nature, and Agriculture, indicated that extended periods of drought, alongside higher temperatures, could have negative effects on the availability of potable water and have further ramifications on public health, agriculture, nature, and shipping. Additionally, the Flemish Environment Agency (n.d.) specified on its online climate portal that smaller river valleys are more sensitive to hydrological drought than larger ones.

4.3.2 Developing Adaptation Strategies: Differences in political views hindering the collaboration between the Flemish government and the city of Leuven

A National Climate Commission has been established in 2002 to create synergies and consistency between various levels of power. It is considered as the main coordination structure with reference to the national climate policy. The 2003 heatwave and its severe impacts in Belgium stimulated the establishment of the first Belgian 'Ozone and heatwave plan', which came into effect as of the summer of 2005 (Flemish Environment Agency, n.d.). A National Climate Plan (NCP), based on measures and policies developed by each of the federal states and the 3 regions, has been

elaborated and adopted in 2009. This plan remained in application until the development of the Belgian National Energy and Climate Plan (NECP 2030) which was approved by the Consultation Committee in December 2019. The Belgian National Climate Commission (2017) stated in a national communication report that the absence of a climate national plan for the period 2013-2020 is somewhat counterbalanced by the existence of regional plans.

A National Adaptation Strategy (NAS) was developed by the Belgian National Climate Commission in 2010 describing the main impacts, the adaptation responses in place as well as a roadmap to the development of a national adaptation plan and policy guidelines. It highlighted that a considerable part of the necessary adaptive measures has already been introduced from the bottom up. The NAS (Belgian National Climate Commission, 2010) affirmed that “both on the local level as on sector-specific level, the sense of urgency has inspired many people to take action in fields as diverse as health, tourism, agriculture, forestry, biodiversity, ecosystems, water, coastal, marine and tidal areas, production systems and physical infrastructure”.

A National Adaptation Plan (NAP) was adopted in 2017, identifying adaptation measures to be taken at the scale of Belgium to ensure cooperation and strengthen synergies among various entities addressing climate change. The plan tackles 6 fields: health, biodiversity, energy, crisis management, international cooperation, and research. It highlights that adaptation measures are to be developed and implemented by local and regional authorities in the framework of their proper climate policy. The Belgian National Climate Commission (2017) clarified in a report that the NAP raises the importance of coordination in the planning and management of climate-related emergencies and aims at promoting transnational cooperation on climate change adaptation to learn and exchange best practices. The actions presented in the NAP include the development of climate scenarios and projections, the establishment of “Climate Center of Excellence” as a one-stop-shop for climate-related research as well as a national online website for adaptation to climate change. The NAP also embraces the reinforcement of sectoral coordination in Belgium, the inclusion of climate change in risk analysis, the evaluation of the effects of climate change on energy security, societies, and the economy. It sheds light on the importance of including the impacts of climate change in the future “National Environmental Health Action Plan” and on raising awareness on the matter among workers and professionals in the medical and health field.

A Belgian mid-sized city like Leuven presents an interesting case study as the country has a federal structure and the power of policymaking and responsibilities are shared among the national federal state, the three Belgian regions, and the three communities as well as municipalities. Consequently, climate policies are developed and implemented by various governmental levels which set their objectives and priorities based on the scope of their competencies. Each of the federal and regional governments has embraced its own adaptation plan according to its area of competencies. Moreover, some provincial and local governments have developed their proper adaptation plans, asserted an environmentalist and researcher at the KU Leuven (interview, 2021). He elucidated that the federal authorities, including Flanders, have major responsibilities in territory related areas crucial to climate change adaptation such as urban and rural planning, water policy, public works, transport infrastructure, nature conservation, and the promotion of renewable energy sources

The first Flemish Climate Plan (VKP) (2002-2005), approved by the Flemish government in February 2003, introduced climate measures at the scale of the territory. A second VKP (2006-2012) was published in 2006 highlighting the importance of climate change adaptation and the willingness of the region to develop appropriate adaptation measures. In 2013, a VKP (2013-2020) consisting of a framework and 2 sections were adopted. The first section includes a mitigation plan, meanwhile, the second section embraces the Flemish Adaptation Plan (VAP) which apprehends the vulnerability of the territory to climate change and addresses ways to improve its adaptability.

The regional adaptation plan (2013-2020) developed by the cabinet of the Flemish Minister of Environment, Nature, and Agriculture, addressed the importance of taking a proactive approach to adaptation rather than a reactive one to limit risks and costs associated with the impacts of climate change. The VAP suggests screening existing policies and developing new ones while considering various climate scenarios. It also calls for creating synergies between adaptation initiatives and other policy matters such as mitigation.

The Flemish Adaptation Plan (VAP 2013-2020) presented various measures that could be used to counter the impacts of climate change on the region. For instance, it underlined the importance of ensuring better management of water resources and improved flood protection. To ensure enhanced protection of the natural environment, the regional adaptation plan emphasized the need for further research and stated that solutions should be site-specific. It also asserted ecosystems could be more robust by ensuring a good level of preservation and intertwining nature with other areas of policy. To ensure better adaptability of the Flemish industry and service sector, the VAP (2013-2020) proposed raising the awareness of actors in the private sector. To increase the adaptability of the transportation system to climate change, the regional adaptation plan suggested a reassessment of civil engineering projects and underlined the importance of roads maintenance. It also stressed the significance of improving the resilience of the built environment to climate events especially that constructions and buildings stand for decades. The VAP (2013-2020) addressed the importance of raising the citizen's awareness regarding health issues related to climate change.

To counter the impacts of climate change on various sectors and to increase the territory's adaptability, the cabinet of the Flemish Minister of Environment, Nature, and Agriculture (2013) laid out 76 specific measures and presented them in the VAP (2013-2020) to be implemented in the following years.

The Flemish Environment Agency (2019) established a drought and flooding action plan (2019-2021). The plan (VMM, 2019) sets the objective to address water related issues through understanding and acting on the impacts of climate change, improving awareness on flood risks, and promoting the rational use of water. It also stressed the importance of limiting flood damage, optimizing water distribution, giving back the water the space it needs, reducing the superficial runoff of water and sediments as well as ensuring a sustainable drinking water supply. For each of the suggested actions whether to address flood or drought issues, the report made a distinction between implemented actions and future plans.

The Flemish government defined 7 areas and themes of priorities in the field of transition for its vision 2050 including smart living, transport and energy, healthcare and welfare, circular economy, a dynamic professional career, lifelong learning, and industry (Associate at the Flemish Environment Agency, interview, 2021). The Flemish government also provides its support to

municipalities and local authorities and incites them to develop their own adaptation measures. Some Flemish municipalities have already started working on adaptation such as Ghent, Antwerp, Hasselt, and Leuven. However, an environmentalist and a researcher at the KU (interview, 2021) working closely with the city of Leuven affirmed that the municipality considers that its climate ambitions are more developed than those of the Flemish region. He clarified that the collaboration between both levels of governance, regional and local, is rather weak due to the difference in political views.

The Province of Flemish Brabant, which is considered an intermediary level between the Flemish Region and the municipality of Leuven, approved a climate policy plan 2040 in the summer of 2016. The province is committed to the European targets for a reduction of at least 40% of greenhouse gases by 2030 as well as adaptation to future climate changes (De Paep, Verachttert, & Van Reeth, 2019).

The city of Leuven has been long committed to sustainability asserted a Leuven municipal councilor representing the Green party (interview, 2020). The municipality first engaged itself with environmental and climate issues in 1998 through the establishment of the platform “local agenda 21” in which it collaborated with a wide group of local actors including companies, civil society organizations, and the university. The transformation of the platform into the “Sustainable Leuven Network” strengthened the dynamics of the city and broadened its operation to include various sectors such as consumption, energy, and mobility (De Paep, Verachttert, & Van Reeth, 2019). In 2010, Leuven stated its ambition to become energy neutral. A year later, it signed the Covenant of mayor, as a declaration of intent to make the city climate neutral (Heyvaert, & Jansen, 2018). This required the formation of a ‘Sustainable Energy Action Plan’ (SEAP). “Ridouani, the current mayor of the city, was an alderman at that time and pushed for an environmental agenda as he was convinced of the importance of making the city climate neutral” asserted an alderman in the board of mayor at the city of Leuven (interview, 2020).

The city of Leuven declared in its climate action plan (Mafliet & Debackere, 2014) that it is aware of the importance of formulating sound climate objectives and targets that are specific, measurable, achievable, realistic, and with a defined deadline. Consequently, for the preparation of a climate action plan that defines the road to assure the city’s climate neutrality, a cooperation agreement was drawn up between the city council and KU Leuven and approved in December 2011. The agreement stipulated that the university would deliver a list of existing initiatives for the reduction of GHG emissions (Environmentalist and researcher at the KU Leuven, interview, 2021). The city also asked for a climate action plan consisting of a vision for the future and a set of measures to achieve its targets. This led to the development of “the transition to Leuven Climate Neutral 2030 – a scientific final report” (Vandevyvere H. et al, February 2013).

The scientific report developed by KU Leuven (Vandevyvere et al., 2013) acted as a foundation for the development of the city’s climate-neutral strategy. It provided an assessment of emissions per sector and offered recommendations to achieve the city’s objectives by referring to two scenarios: The Leuven Climate Neutral 2030 scenario and the Leuven Climate Neutral 2050 scenario. According to this report (Vandevyvere et al., 2013), achieving climate neutrality by 2030 is technically possible, but may not be considered feasible or pragmatic. That is why the city set itself the ambition to achieve climate neutrality by 2050.

A network organization, uniting around 60 stakeholders (including residents, companies, knowledge institutions, and public authorities) was cofounded by the municipality of Leuven in 2013 to achieve climate neutrality. It was named 'LKN 2030' to maintain a sense of urgency to avoid that people mistakenly assume that there is still ample time to work on the climate transition asserted an Environmentalist and researcher at the KU Leuven (interview, 2021). He underlined that the name of this organization was then changed to 'Leuven 2030'. He also clarified that the municipality of Leuven was a key partner of Leuven 2030, sponsored the project, and developed its proper climate action plan (2013-2019) in which it stated how the city as an organization has the responsibility to address the issue. The developed climate plan (2013-2019) translates the scientific report (developed by the KU Leuven at the request of the city) into concrete actions and builds on the city's climate policy that started upon signing the Covenant of Mayors.

In 2013 Groen⁴⁵ (the green party in Leuven) developed a vision for a 'climate-proof city' to properly cope with the consequences of climate change that will be felt despite mitigation efforts. This vision paper (Mertens & Demuyne, 2013) underlined that the 'adaptation' dimension is weak in the proposed policy in the context of Leuven Climate Neutral 2030 and aimed at inspiring the city government to develop a local adaptation strategy. The paper (Mertens & Demuyne, 2013) elucidated that adaptation is not only about focusing on the built environment, but also tackling social vulnerability by developing measures prioritizing social groups that are most affected by climate change. It also emphasized that the adaptation strategy should be used in policy plans such as the new spatial structure plan as well as other urban development decisions (Mertens & Demuyne, 2013). In 2018, the green party came into the municipal coalition and since has been playing an important role in the decision-making allowing climate adaptation actions to move forward in the city of Leuven affirmed an alderman in the board of mayor at the city of Leuven (interview, 2020). He asserted that climate efforts were continued and strengthened after the election of 2018 explaining "that would have not been necessarily the case if a right-wing party would have won the elections". The alderman (interview, 2020) however clarified that the city already has climate ambitions and that this dynamic will not cease to exist due to the pressure exerted by citizens and organizations in the city, such as Leuven 2030.

Leuven 2030 prepared a Roadmap 2025 | 2035 | 2050 (De Paep, Verachtert, & Van Reeth, 2019) together with a large group of experts from various disciplines. The roadmap introduced major challenges that are faced at a local scale and displayed a timeline with the necessary steps to achieve climate neutrality by 2050. It presented the city's climate-neutral ambitions, including sustainable consumption, the local production of renewable energy, collaboration for achieving climate neutrality, innovation, and the sharing of knowledge as well as increasing urban resilience. These ambitions are organized in the roadmap into 13 programs: (1) Retrofitting residential buildings, (2) Retrofitting non-residential buildings, (3) Developing climate-neutral new buildings, (4) Rethinking spatial planning, (5) Assuring a sustainable model shift, (6) Greening the vehicle fleet, (7) Generating green energy, (8) Promoting sustainable and healthy eating, (9) Endorsing sustainable consumption patterns, (10) Developing green and resilience spaces, (11) Ensuring

⁴⁵ Groen Leuven is the ecological party in Leuven. Together with three elected member of a city council, seven municipal councilors, a Flemish member of parliament and many enthusiastic volunteers we are building a green future.

appropriate governance and financing, (12) Involving everybody in the transition and (13) learning and monitoring.

The roadmap (De Paep, Verachtert, & Van Reeth, 2019) asserted that even if Leuven is climate neutral by 2050, measures will still have to be taken to adapt the city to climate change. It affirmed that a strategy to alleviate the UHI effect is being worked out as the city is aiming on limiting the temperature difference between the urban environment and its surroundings to a maximum of 2 ° C by 2035. This strategy will be the basis of an action plan to which all spatial projects are expected to adhere.

To ensure a greener city, the Leuven 2030 roadmap (De Paep, Verachtert, & Van Reeth, 2019) suggested the reduction of space consumption. In this context, the 'De betonstop' (stopping concrete) initiative which the Flemish government wants to realize in 2040 will be implemented in Leuven as of 2025. This means from the specified date onwards, the net intake of open space through urban development in Leuven will be reduced to a minimum (De Paep, Verachtert, & Van Reeth, 2019). According to its green ambition, Leuven is aiming at planting on average 1000 trees yearly as of 2019. The roadmap (De Paep, Verachtert, & Van Reeth, 2019) underlined that the city has over 310 hectares of public green space and aims on increasing the green area by at least 40 hectares to have 350 hectares of green area by 2030. The city of Leuven (2019) asserted in its vision memorandum (Leuven 2019-2024) that priority is given to the increase of the share of greeneries in areas where there is a lack of public green spaces.

As of 2020, the tree species planted in public spaces will be carefully selected to resist heat and drought and help provide shade and purify the air (De Paep, Verachtert, & Van Reeth, 2019). The species which require less fertilizers and pesticides are also preferred. Pesticides are already being avoided by the department Management of the city of Leuven. The private owners of large green areas will be required to follow these principles as of 2025. The roadmap also clarified the importance of diversifying the types of vegetation as monotonous landscaping could be more vulnerable to drought than planting a mix of different species.

The Leuven 2030 roadmap (De Paep, Verachtert, & Van Reeth, 2019) asserted that not only it intends to increase the share of greenery but also aims to protect existing green areas such as the Dijle valley, the Meerdal forest, the Abdijbeek valley, and the Bierbeek valley. These areas as well as newly greened areas will be extended and connected to the urban fabric through green corridors. "This will not only increase the city's resilience but also improve biodiversity and increase the city's attractiveness" asserted the city's roadmap to climate neutrality (De Paep, Verachtert, & Van Reeth, 2019).

The roadmap (De Paep, Verachtert, & Van Reeth, 2019) avowed that the uncertainty of climate predictions is high, but the general trend is clear: the risk of drought and inundations is rising considerably. Therefore, the city of Leuven is preparing rainwater and a drought plan. These plans will have to be revised and updated regularly to stay tuned to new climate scenarios. The roadmap (De Paep, Verachtert, & Van Reeth, 2019) also underlined that water management in an urban environment is a collective task. The people of Leuven as well as the organizations and companies must act. Therefore, various measures could be implemented at different levels such as the collection of rainwater for re-use, the softening of the soil, and the increase of the infiltration capacity (De Paep, Verachtert, & Van Reeth, 2019).

The city of Leuven (2019) affirmed in its vision memorandum (Leuven 2019-2024) that it sees opening up the Dijle as a great opportunity, with which it can create a 'blue-green ribbon' throughout the city. The Leuven 2030 roadmap (Paep, Verachtert, & Van Reeth, 2019) also introduced various measures such as constructing water channels and retention basins and reserving open space areas that could be submerged in the events of heavy rainfalls. The excess water could be filtered and stored and thus have positive consequences on groundwater levels and reduce the negative impacts of droughts. Moreover, the city's roadmap to climate neutrality affirmed that strategies are to be developed reflecting on the control of water usage particularly for water-intensive business activities, such as certain industries and the agricultural sectors, especially in drier periods (De Paep, Verachtert, & Van Reeth, 2019).

The city of Leuven asserted in its roadmap that financing is a key aspect to ensuring environmental transition. To achieve this, various tools will be made available to stir investments such as local climate funds. In the absence of the introduction of a compulsory carbon tax, organizations, local companies, and residents will be incentivized to make voluntary contributions to compensate their carbon footprint (De Paep, Verachtert, & Van Reeth, 2019).

A Leuven municipal councilor representing the Green party (interview, 2020) asserted that the city's roadmap 2025-2035-2050 was an inspiration for the development of the city's new climate plan (2020-2025). The latter builds on the climate plan (2013-2019) and defines the desired results for each of the themes of climate policy.

The city of Leuven (2020) underlined in its updated climate action plan that adaptation is currently somewhat fragmented into various actions, projects, and policy plans without a clear and overarching strategy, while mitigation is already well ingrained in urban energy policy. For this reason, the city is determined to streamline climate adaptation in all relevant policy areas and assure collaboration within the city's organization (initially) and with external actors, organizations and citizens affirmed an alderman in the board of mayor at the city of Leuven (interview, 2020).

The city's climate plan (2020-2025) defines the measures and actions to be taken (*refer to appendix II – table 9*), and for each one, it specifies the concerned actors, the indicators to monitor the implementation of the action, the deadline to develop the action as well as what SDG this action corresponds to.

It is however important to underline that only 14% of the measures proposed in the city's climate action plan (2020-2025) are directly addressed to adapt the territory to climate change (*figure 33*). Most of the measures are mainly focused on energy management and sustainable development. Some measures such as assuring an integrated urban climate policy and sustainable urban development as well as related actions serve climate adaptation but are rather general.

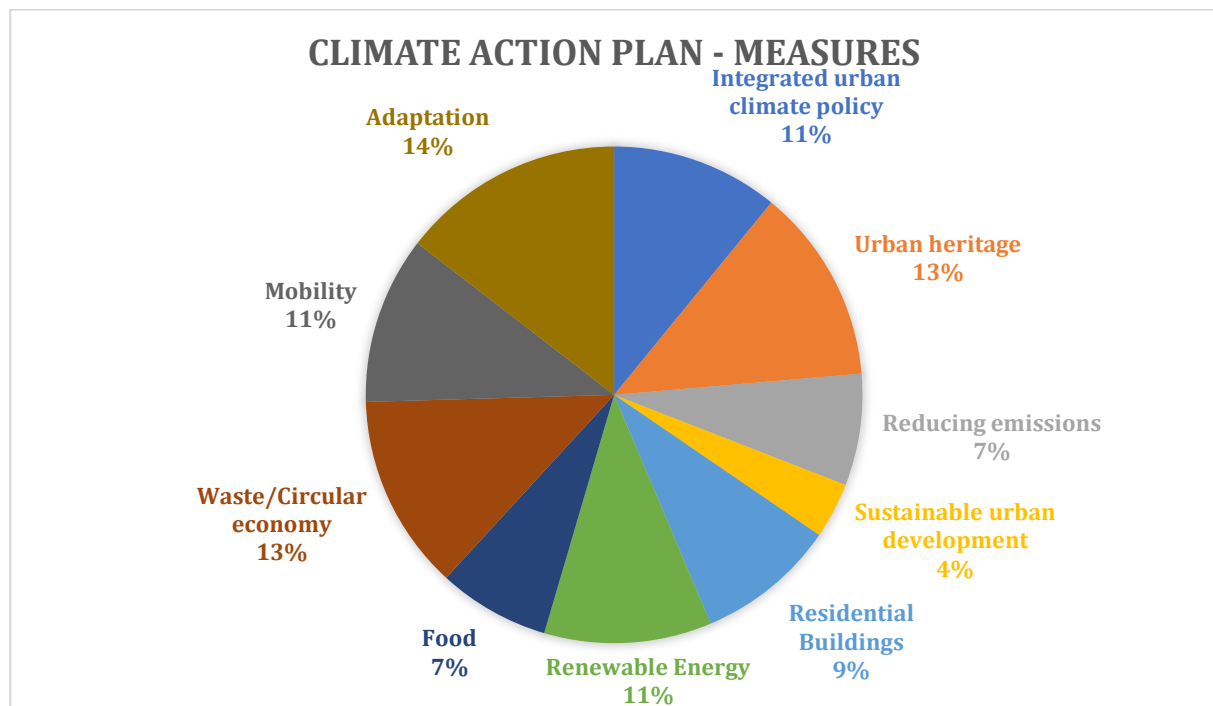


Figure 33 Categorization of climate measures as defined by Leuven's climate plan (2020-2025).

The city of Leuven (2020) avowed through its climate plan that it is aiming at developing a comprehensive urban policy, reinforcing, and ensuring city-wide cooperation, and promoting innovative financing and climate investments. Leuven wants to brand itself as a role model city in the area of climate action and plans to enhance communication on climate and environmental issues and raise public awareness. To do so, and as underlined in its climate plan (2020-2025), it is planning on cooperating with youth and sports associations, and businesses and organizing events in the spirit of climate policy such as a climate week, the city nature experience, and conferences. The city of Leuven (2020) affirmed that it has the objective of integrating sustainability principles into the workflow for city buildings projects as well as monitoring and optimizing building managements systems and pursuing an efficient use of space. It also underlined in its climate plan (2020-2025) that it wants to make the city's heritage more sustainable by ensuring the renovation of existing city buildings and cooperating with real estate actors to find innovative solutions allowing to improve the energy performance of valuable buildings while respecting heritage values. Additionally, it presented its objective of ensuring sustainable urban development and achieving sustainable mobility, promoting sustainable agriculture, reducing CO₂ emissions, increasing the share of renewable energy, and strengthening waste prevention as well as endorsing a circular economy.

Leuven's climate plan (2020-2025) highlighted that a 'spatial optimization analysis', determining the available space of the territory of Leuven and presenting the conflicts and synergies with other policy objectives, is important to ensure the efficient use of space in terms of climate adaptation. It proposed strengthening the city's main blue-green infrastructure through creating links between large blue-green structures and smaller ones in residential cores to ensure a coherent green fabric or network. It highlighted that further area-based research is required per district to prioritize actions and determine what measure is needed and where. In addition to expanding and conserving green areas, the city of Leuven (2020) affirmed in its climate plan that it aims at

establishing a respective protection plan, developing a GIS analysis on the potential for additional green areas, cooperating with nature associations, and promoting the greening of semi-public and private spaces. It also underlined that it has the intention to implement a green standard in urban development projects and developing communication campaigns (both internally and to external partners) stressing the sustainable multifunctionality of urban green areas.

To address the issue of heatwave, the city of Leuven (2020) affirmed in its climate plan (2020-2025) the importance of developing communication and emergency measures in case of heatwaves as well as elaborating a heat strategy which presents measures to protect citizens from rising heat. It proposed executing a rainwater plan through investing in projects such as rain squares, buffer basins and Wadi⁴⁶s, and adjusting the watercourse management. It also suggested adapting the regulations of spatial policy and water-policy to ensure a water-neutral development (City of Leuven, 2020). Lastly, the climate plan underlined the importance of combatting drought through developing an action plan, based on vulnerability studies, including drought control in the construction and management of public domain, assuring the reduction of groundwater consumption, and adapting the urban development regulations (City of Leuven, 2020).

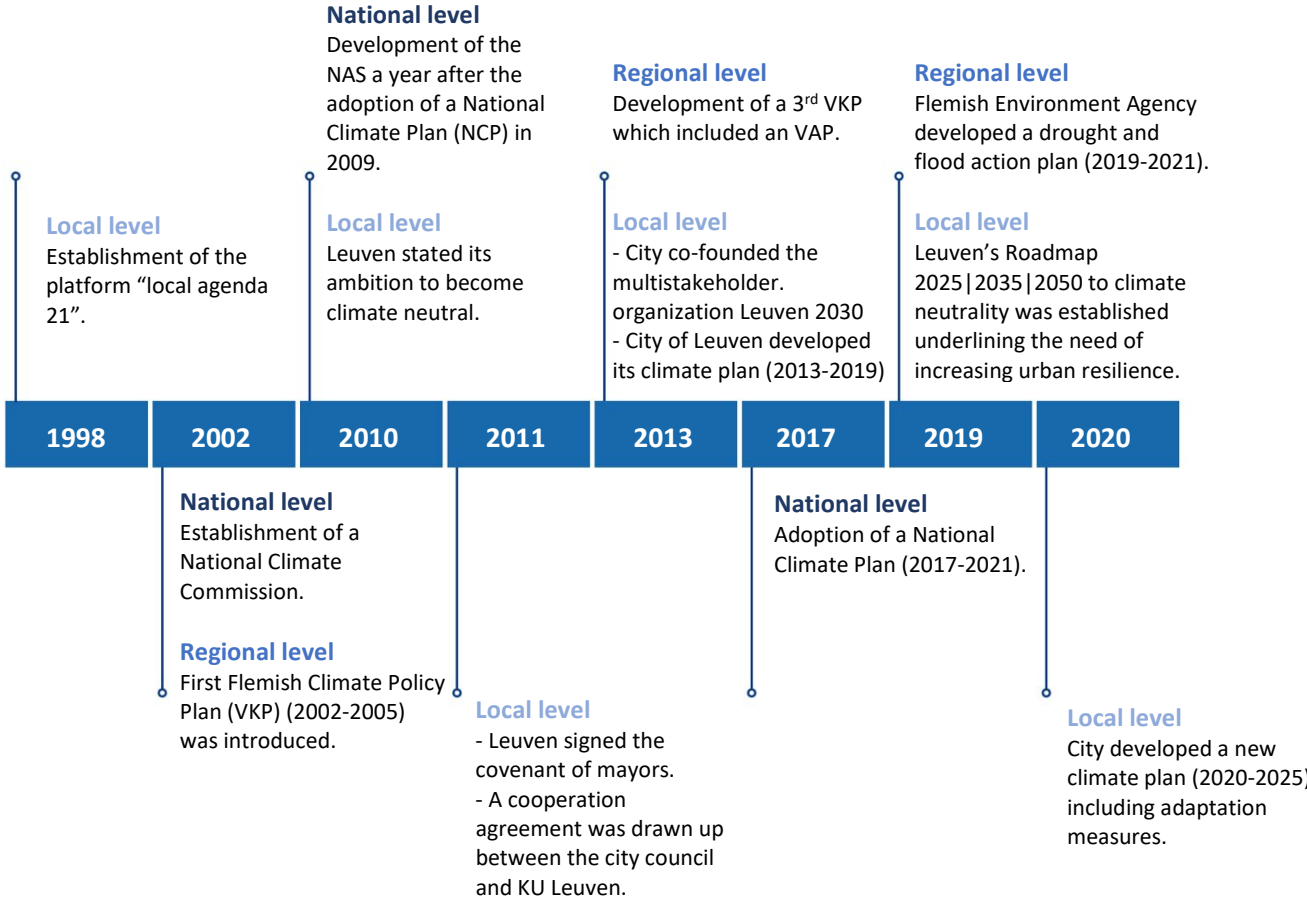


Figure 34 Timeline of strategy development at a national, regional, and local scale serving climate adaptation in Leuven.

⁴⁶ System aiming at capturing, transporting, and storing rainwater to avoid it from being mixed with sewers.

The timeline of strategy development at a national, regional, and local scale serving climate adaptation in Leuven, presented in the figure above (*figure 34*), shows that the city of Leuven has been committed to achieving sustainable development for over 2 decades as it has established a “local agenda 21” platform at the end of the 1990s. The Flemish government has also been proactive in addressing climate issues as it has developed its first climate policy plan in 2002 before the development on a national climate plan (in 2009). The first regional climate policy could have influenced the city of Leuven’s ambition to become climate neutral. Additionally, efforts to adapt the city and increase its resilience in the face of climate events were only considered by the city of Leuven half a decade following the development of a Flemish adaptation plan in 2013. This stresses the influence of plans, actions and measures developed at a regional scale on the development of strategies at a local scale. It also shows that in the city of Leuven more attention is given to sustainable development and mitigation measures rather than adaptation.

4.3.3 Implicating and Mobilizing Actors: The non-profit organization ‘Leuven 2030’ ensuring collaboration among various actors within the city

In Belgium, Federal and regional governments bear the responsibility of ensuring the engagement of various stakeholders in the development and implementation of adaptation plans.

In 2010 and 2011, the Flemish Environmental Agency (VMM) organized a series of workshops in the city of Leuven, and invited water authorities, emergency services, local administrations, sectors of society as well as licensing and advisory authorities, to identify solutions and discuss measures to address the issue of anticipated floods in Flanders (La Rivière, 2015).

Upon the adoption of the Flemish climate plan (VKP 2013-2020), an online platform⁴⁷ was launched suggesting a vast range of topics on which Flemish citizens can contribute to ensuring a healthier climate.

The present Flemish adaptation plan (VAP 2013-2020) was drawn up by a coordinating adaptation taskforce (VTFA⁴⁸) jointly with the Department of Environment, Nature and Energy. The VTFA consists of staff from various policy areas including economy, science and innovation, agriculture, spatial planning, public health, water management among others. It was established to assure for exchange of knowledge and grant synergies across various policy fields asserted an associate at the Flemish Environment Agency (interview, 2021).

According to the European Environment Agency (2019) and as presented on the ‘Climate Adapt’ online portal, the Flemish government presented its adaptation plan for stakeholder consultation in two rounds. The first round was to develop the primary ideas and set them on paper, the second one was to propose the draft version to different advisory boards. Moreover, the Flemish environment agency asserted in its drought and flooding action plan (VMM, 2019) that various stakeholders were involved in the preparation of the plan to ensure coherence and underlined the importance of shared responsibility.

A ‘think tank’ consisting of experts, academics, and other researchers on adaptation with a concentration on spatial planning was subsidized for 3 years by the Flemish government (2015-2017) to jointly develop and disseminate knowledge on adaptation. This ‘think tank’ shed the light

⁴⁷ www.klimaattips.be.

⁴⁸ Vlaamse task force adaptatie.

on required tools as well as barriers and opportunities to the implementation of adaptation strategies affirmed an associate at the Flemish Environment Agency (interview, 2021). He added that in Flanders, universities, and colleges regularly organize awareness campaigns and are urged by the Flemish region to include sustainability and environmental care within their organizations. The regional governments support and encourage local municipalities and cities to develop their own action plans and to sign the Covenant of Mayors by providing necessary funds and tools (Associate at the Flemish Environment Agency, interview, 2021).

On the 2nd of May 2011, the city council in Leuven approved the participation in the initiative "Covenant of Mayors" by signing it. Through this agreement, the city council declared its commitment to reduce GHG emissions on its territory by at least 20% on the horizon 2020 and to switch its energy supply to renewable sources to a significant degree. As a member of 'Mayors Adapt' the city focuses on adaptation as well.

When it was first established, the LKN2030 project started as an initiative of several civil society organizations, the municipality as well as the University of Leuven and united around 60 stakeholders. Today, this independent organization, known as 'Leuven2030', brings together around 500 members and plays a crucial role in stimulating climate-neutral and sustainable development projects and initiatives in the city (Leuven municipal councilor representing the Green party, interview, 2020). The organization offers a platform for collaboration among various actors, feeds the social debate, and ensures a bottom-up approach to addressing urban climate challenges.

The Leuven 2030 organization is embracing this participatory approach assured an alderman in the board of mayor at the city of Leuven (interview, 2020).

A local policy was established to develop communication towards the city's staff regarding the targets for climate neutrality by 2030. The policy also includes awareness-raising and stresses the importance of external communication to inform the public (Malfliet & Debackere, 2014). In this context, the municipality is focusing on education and stirring climate-projects in schools underlined the city of Leuven (2017) in its application for the European Green Leaf award. It elaborated that awareness campaigns and various activities are developed to address various themes. For example, to shed the light on the importance of sustainable urban mobility, the last Sunday of August is the "annual car-free Sunday". Not to mention, the city aims at motivating its citizens to engage in climate-neutral objectives through proposing free professional consultation, following up on renovation plans, and offering financial incentives like benefits and interest-free credits for energy-efficient projects and initiatives (City of Leuven, 2017).

The city of Leuven (2017) asserted in its application for the European Green Leaf Award that it conducts public consultations to get feedback from citizens on proposed measures and initiatives, then incorporates them in the last version of the plan, in efforts towards assuring participatory governance. The city's roadmap to climate neutrality (De Paep, Verachtert, & Van Reeth, 2019) affirmed that a comprehensive and systemic transition is the result of intensive cooperation within a transparent framework and can only succeed if it is worn by all actors involved. The city of Leuven (2019) avowed in its vision memorandum (Leuven 2019-2024) that it aims on establishing a cross-municipal cooperation platform to address local transcendent issues in collaboration with

neighboring municipalities. Leuven is also part of international networks such as Eurocities and CIVITAS to share knowledge and exchange ideas with other cities and municipalities globally.

A strategic transition arena at a policy level was also established, the "G20 for Leuven Climate Neutral". Many partners from the business world, civil society, research, and education sector, and other (semi) public bodies were represented on the supervisory committee. In this initiative, every resident of the city of Leuven is invited to become an 'ambassador' encouraging other residents or organizations to deliver their own vision for a climate plan (CIVITAS, 2013).

The city of Leuven (2019) underlined in its vision memorandum (Leuven 2019-2024) that it considers experts and environmental organizations as key partners in the creation and the management of green areas and natural environment and supports their operation. In 2018, the 'Leuven 2030' organization collaborated with BUUR, an urban planning agency, as well as various experts, to develop its roadmap 2025 | 2035 | 2050 to achieve climate neutrality by the set horizons.

The Leuven 2030 organization (n.d.) presented on its online platform⁴⁹ that it provides tools allowing for various actors to calculate their own ecological footprint and prepare their own climate action plans. Moreover, together with various partners the organization develops pilot projects and experiments which contribute to a climate neutral future. It gives visibility to sustainable initiatives from within and outside Leuven 2030 and addresses relevant actors on their role and responsibility in achieving the Leuven climate objectives. Local companies and businesses are involved in Leuven 2030 as the organization believes it is important for this sector to share and act on climate ambitions affirmed an alderman in the board of mayor at the city of Leuven (interview, 2020). He however expounded and underlined that "what is more important than involving businesses, is verifying whether their engagement is real, as being simply a member without an active engagement will not yield benefits". The city is nevertheless working alongside companies and industries that are located in the industrial zone bordering the cities to investigate how to include adaptation in that area through increasing the permeability of the ground by developing green areas and reducing the areas of hard surfaces (Alderman in the board of mayor at the city of Leuven, interview, 2020). Additionally, the city of Leuven is involved in the European climate project and is collaborating with climate KIC knowledge and innovation center on three projects on which one is focused on involving businesses and companies in climate adaptation (Alderman in the board of mayor at the city of Leuven, interview, 2020).

The city's climate action plan (2020-2025) defines the role of each department in addressing the issue of climate change. For instance, the Directorate of Spatial Development and Sustainability at the city of Leuven is responsible for monitoring and developing the overall climate-strategy of the city. The operation of the department is focused on a city-wide climate policy and developing impactful projects that are worked out together with different city services. The Directorate of Data and facility management bears the responsibility of implementing the action plan and assuring the management of urban heritage buildings. The Department of Road and Water Management should work on the design and implementation of projects in the public domain including the redevelopment of squares and streets in support of green and adaptation policies. The Green Management Department carries the duty of developing green policies as well as

⁴⁹ <https://www.leuven2030.be>.

policies to ensure the permeability of the city therefore works closely with the Department of Road and Water management and is largely responsible for climate adaptation.

According to the city's action plan (2020-2025), various other services and departments are responsible for the implementation of specific sub-projects. The city of Leuven (2020) affirmed in its climate action plan that it finances the Autonomous Municipal Urban Development which ensures the coordination of projects that fall within the regular operation of one of the urban departments.

4.3.4 Implementing Developed Strategies: A series of various small-scale initiatives to increase the climate resilience of the territory

The Belgian National Climate Commission (2017) presented in the seventh communication report on climate change the adaptation measures that have been implemented in various sectors in Belgium. For instance, in water management, information campaigns were conducted to disseminate information and encourage water savings. The country updated the part on floods in its national emergency plan which anticipates prevention measures such as defense mechanisms protecting the territory from high tides. Regional plans were also developed to set a management framework and ensure the prevention of flood risks (Belgian National Climate Commission, 2017). The report (Belgian National Climate Commission, 2017) also affirmed that in the IVB interregional project "Future Cities – urban networks to face climate change" was established to adapt the urban environment and infrastructures to anticipated climate impacts. Impacts assessments have been conducted using CORDEX, a framework to evaluate regional climate performance through a series of experiments aiming at producing climate projections at a regional scale. The adopted approach allowed for an improved understanding of climate impacts on urban environments (Belgian National Climate Commission, 2017). Additionally, to address health issues, a call for the development of e-training modules has been launched for medical specialists and doctors to consider the impacts of climate change on health (Belgian National Climate Commission, 2017). A casual observation reveals that the measures that are implemented at a national scale are mainly concerned with producing and dissipating knowledge as well as developing plans to address climate challenges.

In Flanders, a website⁵⁰ was developed providing information on GHG emissions, best practices as well as relevant adaptation projects at the scale of the territory. Also, at the end of 2016, the Flemish government developed a local covenant of mayor's platform⁵¹ to support local authorities to convert their commitment into practical measures. The Flemish government (2017) asserted in its progress report 2016-2017 for the Flemish Climate Policy Plan that the issues of climate and energy are addressed in the context of awareness-raising in all types of schools (primary, secondary, higher education). It also presented that it has assured the adjustment of the curriculum of some technical courses such as construction and electricity. It affirmed that these adjustments are crucial given that workers in the building industry (Engineers, architects, construction works, etc.) will increasingly be confronted with the obligations to consider climate change and integrate sustainable construction techniques when developing new projects and

⁵⁰ <https://klimaat.vmm.be/nl>.

⁵¹ www.burgemeestersconvenant.be.

exhaustive renovations. The progress report (2016-2017) also asserted that existing buildings are systematically tackled depending on the real estate situation (ownership, duration of current lease contracts, etc.), especially in terms of energy performance and user comfort (Flemish Government, 2017).

The Flemish Environment Agency (VMM) (2019) in its drought and flood action plan (2019-2021) presented the actions that have been undertaken as well as actions to be implemented in the future. To list some of the ongoing actions, the Coordination Committee on Integrated Water Policy is investigating whether the code for the design, construction, and maintenance of sewer systems needs to be adjusted and updated to ensure climate-resilient and robust infiltration. Moreover, the Flemish government is working alongside local authorities and stakeholders on a climate buffer program offering easily accessible and sheltered areas for cooling and green-blue infrastructure to protect against flooding.

The VMM (2019) underlined that every year around 20 to 21 million euros are made available to address floods, water scarcity, and droughts. It elucidated that most of these funds go to investment projects and the maintenance of watercourses. In recent years, a budget was dedicated to refining the drought and flood policy (including climate aspects) affirmed an associate at the Flemish Environment Agency (2021) in an interview. He explained that the Flemish government supports good practices and innovative projects through establishing subsidy programs granted to companies, local authorities, and associations such as the 'Living Labs' funds', the 'Green roofs and green facades', and the 'Water-Land-Schap' projects.

Leuven asserted in its climate action plan (Malfliet & Debackere, 2014) that it guarantees the implementation of its climate-neutral policies by embedding them within the regular operation of various city services. An online platform⁵² was developed to shed the light on the Leuven 2030 climate neutral strategy. The website presents the city's roadmap, mission, and objectives as well as the main themes that are being addressed (buildings, mobility, energy, agriculture and food, nature, and consumption). Moreover, it gives access to scientific reports which inform on a list of possible and necessary measures in addition to an overview of possible scenarios for achieving a climate-neutral city. Lastly, the platform highlights the projects that have been developed in the city within the climate-neutral initiative and for each project, it states the involved partners.

Measures to protect the city of Leuven and increase its resilience to weather events were in place for decades even before developing an understanding of climate change and its impacts on the environment and the territory. Following the flood of 1891, the city requested the setting up of a committee to examine the reasons behind the flood and address the problems (La Rivière, 2015). The committee suggested constructing barrages and dikes along the Dijle River and proposed to adjust existing legislation. Around the 1950s, changes in legislation made the province of Brabant responsible for managing and maintaining the Dijle River (La Rivière, 2015). Following the 1980 and 1981 floods, the measures in place and the clearance of the river from accumulated debris proved to be insufficient and the city proceeded to raise and fortify the dikes (La Rivière, 2015). The city of Leuven is becoming more aware of the importance of adapting to climate change. However, "to date, only a few adaptation-specific projects have been implemented given that it is a "new" area of focus at the city scale" asserted an environmentalist and researcher at the KU

⁵² <https://www.leuven2030.be/>.

Leuven (2021). The city developed various small-scale measures and therefore, “the challenge now is to develop more in big scale projects which requires ‘having everyone on board’ including various city departments and the citizens” declared a Leuven municipal councilor representing the Green party (interview, 2020).

The city of Leuven (2019) proclaimed in its vision memorandum (Leuven 2019-2024) that it is mainly working on measures that allow, on one hand, to ensure high levels of groundwater capacity to protect the urban area in the events of heavy rainfall; and on the other hand, to soothe the climate during hot summer by opening waterways where possible.

In 2010, the city of Leuven was very close to being submerged as the capacity of the flood reservoir was surpassed. Since, it became aware that, despite efforts to develop controlled flood areas and flood reservoirs, more work needs to be done to cope with extreme weather conditions in the light of climate change. Terrens, Haesevoets, & Nuyts (2011) affirmed that “...a great deal of infrastructure, including city centers, is not protected and in practice, such protection is also difficult to achieve”, thus additional measures or new approaches are needed to increase the city’s resilience to climate change to deal with ‘unavoidable’ consequences.

Today, to protect itself from floods, the city relies on innovative solutions instead of strictly hydrological engineered solutions affirmed a Leuven municipal councilor representing the Green party (interview, 2020). He expounded that a lot of work was done to construct flood management structures and give back the floodplain to the Dijle River. Valley-grounds have been restored to become natural flood zones and have the capacity to store more than 2 million m³ of water in a natural way asserted the city of Leuven (2017) in its application for the European Green Leaf award. It elucidated that, over the last decade, a lot of work was dedicated to water management and wastewater treatment making Leuven one of the most equipped municipalities in the whole Flemish region. Concretely, the number of constructions connected to the sewage system increased by 16% to reach 96% and the number of households connected to wastewater treatment plants increased by 33% to reach 93% (City of Leuven, 2017).

The city is aiming at reconnecting its citizens to the river through increasing the number of blue zones which are considered a buffer to climate change (Alderman in the board of mayor at the city of Leuven, interview, communication, 2020). As a case in point, the presence of water, green spaces, and historical heritage was predominant in the redevelopment of Vaartkom, a large-scale urban renewal project transforming an industrial site of nearly 30 hectares into a multifunctional urban development project (Geerts, 2017). The demolition of many buildings was done, opening up the Dijle and putting it in the spotlight by re-establishing the contact between city dwellers and the watercourse. It also freed up the spaces required to ensure the greenery of the Vaartkom and its connection with the city center (Geerts, 2017). The Sluispark was the first in a series of new parks to be developed in the Vaartkom. The banks of the Vaart and the Victor Broosplein were remodeled into places for public interaction (*figure 35*). The water element plays a central role at this park as it offers large steps leading to the water and a water play area for kids (De Paep, Verachtert, & Van Reeth, 2019). Citizens were invited to provide feedback on the design and their ideas affirmed the City of Leuven (2021) in a communication on its official website.



Figure 35 Vaartkom Urban redevelopment Leuven. Source: Geerts, 2017.

The city of Leuven (2017) declared in its European Green Leaf award application that it aims on encouraging the re-use of rainwater through employing legal and financial incentives to address the issue of water scarcity. For instance, the construction of rainwater tanks and pumps is made mandatory for new constructions or exhaustive renovations (City of Leuven, 2017). Also, taxation on water consumption is imposed and a metering system is implemented to increase the citizens' awareness on water savings. Moreover, the city subsidizes the construction of rainwater installations in existing dwellings as well as the construction of green roofs and infiltration units (Alderman in the board of mayor at the city of Leuven, interview, 2020). The city of Leuven is aware that in addition to its standard functions (increasing the attractiveness of the city and the creation of recreational areas), increasing greenery can be used to combat the UHI effect and contribute to the adaptation of the city to climate change, affirmed a Leuven municipal councilor representing the Green party (interview, 2020). He asserted that the city is through various means working on developing its blue and green urban spaces.

The surface of green areas managed by the municipality has increased from 200 hectares to 300 hectares in a decade and a half (Heyvaert, & Jansen, 2018). According to the city of Leuven (2017) and as presented in its application for the award, 42.7% of the total area of Leuven is green, this percentage is the second-highest one in comparison to the 13 Flemish center cities. In 2014 more than 80% of the city's population were living within a walking distance from green parks (within 400 meters) (City of Leuven, 2017). Large trees are provided in squares and parking lots and water elements are emphasized or installed due to their soothing and refreshing qualifications (De Paep, Verachtert, & Van Reeth, 2019).

"The city believes that the participation of local citizens in the enactment of urban policies is of great value" (Alderman in the board of mayor at the city of Leuven, interview, 2020). As a case in point, the 'Stand up for your neighborhood' ("Kom op voor je wijk") project was carried out by the local municipality to incite bottom-up initiatives such as small-scale urban interventions. The city of Leuven (2017) asserted in its European green leaf award application that, to support this project, financial and logistic assistance are offered for developing sustainable projects which are a result of a group process and collaboration among neighbors, to improve the living quality of the neighborhood. Moreover, technical, and financial support is offered by the city to private

properties for the plantation of front yards and the creation of green façades (Alderman in the board of mayor at the city of Leuven, interview, 2020). The municipality also offers financial aids to environmental associations working on the management of sanctuaries, the conservation and the protection of species and their natural habitats, and the preservation of biodiversity (De Paep, Verachtert, & Van Reeth, 2019).

The city of Leuven (2017) declared in its application for the award that it developed the “1001 trees for Leuven” project in collaboration with engaged citizens and environmental organizations to increase the share of greenery in both public and private domains. Moreover, the municipality is collaborating with schools to raise awareness through The CONDOR project which aims at inciting students to green their schools. The project stresses the importance and the necessity of cultural change which starts at school (Alderman in the board of mayor at the city of Leuven, interview, 2020). The city is also encouraging its citizens to plant their own food in community gardens or their private gardens and to purchase local products (City of Leuven, 2017). The ‘Leuvense voedselstrategie’ or the ‘Leuven food strategy project’ was developed to support sustainable agriculture in the city (Environmentalist and researcher at the KU Leuven, interview, 2021).

The City of Leuven (2017) also presented its “Straten Vol Leuven” (Crowded streets) initiative in its European green leaf award. Through this project, the city is committed to contributing to a better quality of life, accessibility, and mobility, and reducing the pressure on the environment by making Leuven’s city center car-free. The initiative adapts the layout of the public domain to the slow traffic and focuses on keeping the city accessible by giving pedestrians and cyclists more space. The objective of this project is to promote the health of the citizens and the visitors by exposing them to less pollutants. “This initiative supports the development of the Green city Leuven is aiming at creating” affirmed an environmentalist and researcher at the KU Leuven (2021) in an interview; elucidating that upon the implementation of a new mobility plan more parking space became available and is now in the process of being turned into green areas.

The City of Leuven (2020) asserted in its climate action plan (2020-2025) that working on climate targets is inherent and ought to become a regular operation within the municipality. It however clarified that this could make it challenging to determine the specific cost allocated to climate adaptation as the cost of climate policy is spread across many sectors and services.

To assure transparency, the city is working on improving communication with its press services affirmed a Leuven municipal councilor representing the Green party (interview, 2020). He explained that, for instance, when a new project is being developed, citizens are informed about the process of its development by receiving a letter in their mailbox. He added that the city communicates its multi-year budget once it is defined and set and provides information on the projects that are developed and implemented.

In its multi-year budget for 2014-2019, the municipality dedicated more than 12 million euros for measures directly contributing to the city’s climate-neutral objective (Malfliet & Debackere, 2014). The budget distribution (*figure 36*) shows that the municipality is mainly investing in energy policies including the energy renovation of buildings it owns. The city also spends around a quarter of its budget on sustainable mobility projects. The smallest budget is dedicated to the sensibilization of schools, and the coordination of the urban activities that align with the city’s

climate-neutral objectives, including studies. It is, however, important to underline that in addition to the budget dedicated for measures directly contributing to the city's climate-neutral objective, budgets are provided for the regular policy which also aligns with the city's 2030 objectives (Malfliet & Debackere, 2014).

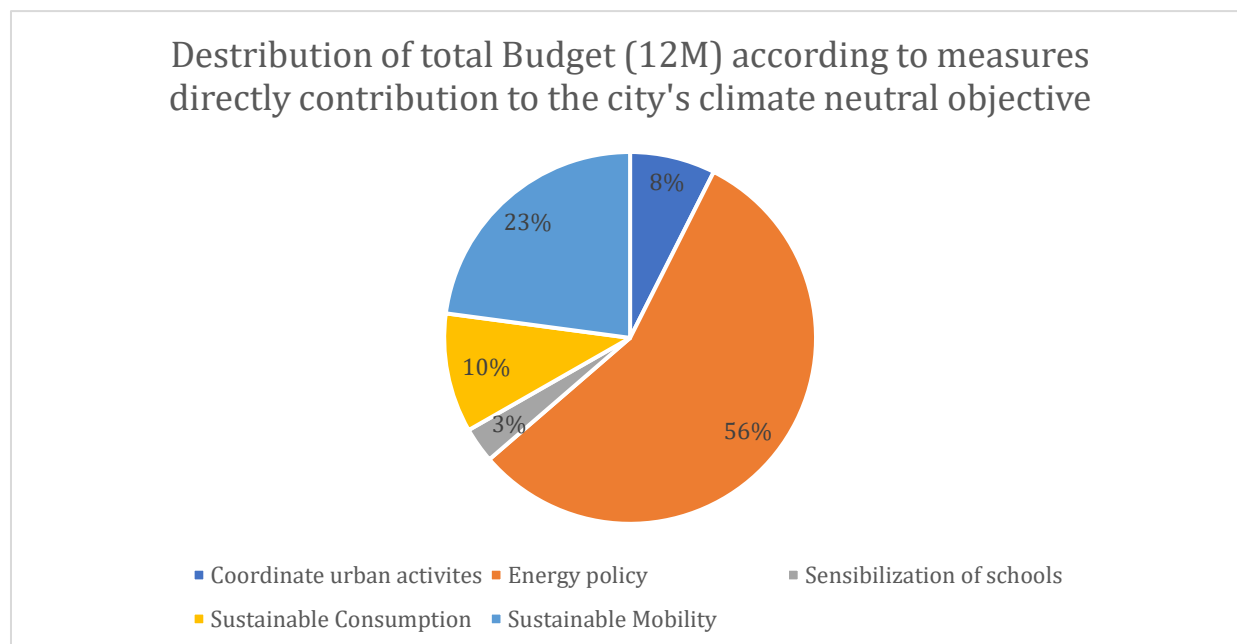


Figure 36 Distribution of Leuven multi-year budget for 2014-2019 according to environmental measures. Source: Malfliet & Debackere, 2014.

“The big advantage that the city has is that the municipality is working alongside the local university which assures the production of knowledge, the availability of human resources and technologies necessary for the implementation of adaptation projects” asserted an Alderman in the board of mayor at the city of Leuven (interview, 2020). He explained that “having the right people in the city's administration is absolutely necessary, and the municipality is currently investing in that”. This was confirmed by a Leuven municipal councilor representing the Green party (interview, 2020) which stated that the municipality has a professional staff and the availability of people with the right knowledge is not really an issue. An environmentalist and researcher at the KU Leuven (interview, 2021) however underlined that the city has a dense urban fabric which limits the availability of lands in some cases for the implementation of projects (e.g., the incorporation of greenery in densely built areas), affirming the need for creative urban environmental solutions.

4.3.5 Monitoring and Evaluation: Need for data availability at the scale of Leuven

On a national level, monitoring has been implemented since 2015 and its results are included in National Communication reports and can be accessed online.

The National Adaptation Plan (NAP) (2017-2021) developed a monitoring and evaluation system in which at least one qualitative or quantitative indicator is identified to assess the implementation of each of the defined measures. For example, to assess the establishment of a national online website for climate adaptation, the ‘Adaptation’ working group at the National Climate Commission examines whether the platform has been created as well as statistics on the number

of visits. To follow up on the implementation of measures, a mid-term evaluation is conducted in 2018 identifying weaknesses and strengths in the implementation to correct any potential shortcomings. A final assessment is to be conducted by the end of 2021 identifying possible gaps, methods to address them, and defining whether an updated version of the NAP is needed. The first evaluation of the NAP (2017-2018) is publicly available at the national platform on adaptation⁵³.

The Flemish Adaptation Plan (VAP) (2013-2020) -developed by the cabinet of the Minister of Environment, Nature, and Agriculture- asserted that to follow up on adaptation policies, periodic sector-based meetings should be organized to assess the progress and the development of corresponding adaptation measures in various domains. The outcome of these meetings should be presented to the adaptation task force (VTFA).

The Flemish Environmental Reporting Service (MIRA) is responsible for evaluating the environmental policy and the implemented actions. Sectorial pilots must report on the actions defined by the VAP on a 2-yearly basis (Associate at the Flemish Environment Agency, interview, 2021). Accordingly, two reports on progress on climate change, comprising a section on adaptation, have been developed and published by the Flemish government in 2015 and 2017. The third progress report is yet to be published including a final evaluation of the VAP 2013-2020. These progress reports define, in consultation with the relevant authority, the progress on adaptation actions. They distinguish between the actions that are executed, the ones that are on schedule, the ones that are facing delays or are only partially implemented, and the measures that haven't been implemented. They also indicate when there is a lack of information about specific measures.

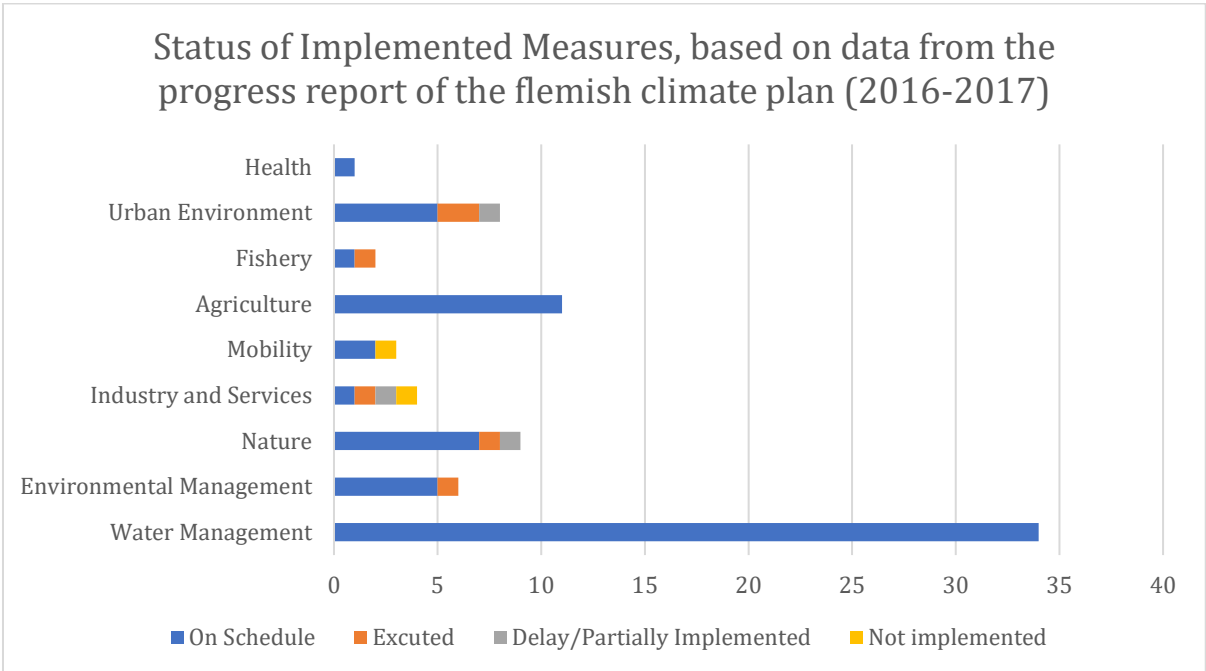


Figure 37 Status of Implemented Measures, based on data extracted from the progress report of the Flemish climate plan (2016-2017). Source: Flemish Government, 2017.

⁵³ <https://www.adapt2climate.be>.

The chart above (*figure 37*), based on data extracted from the progress report (2016-2017) of the Flemish climate plan, shows that the status of implementation of measures is not uniform in all fields and sectors.

Most adaptation measures in Flanders are addressing the area of water management (34 measures). This underlines the importance and priority that the city is giving to this area of intervention. Other areas of action such as health, fishery, mobility as well as industry and services seem to relatively have a “negligible weight”, this highlights that the regional government is not investing much in the implementation of measures in these fields. Some measures in the areas of agriculture, urban environment, nature, and environmental management are executed or being implemented. However, there is still room for the intensification of efforts in fields and sectors outside of water management.

An Associate at the Flemish Environment Agency (interview, 2021) affirmed that the regional government is working on developing more thorough monitoring and evaluation adaptation system and indicators for its VAP 2021-2030.

The Province of Flemish Brabant Environment Department (2016) asserted in its climate policy plan that, at the scale of the province, targets, as well as qualitative and quantitative follow-up indicators, are defined for each action in the 2016-2019 climate action program. It elaborated that these indicators are followed up in a time-efficient manner affirming that “monitoring makes it possible to determine the contribution of the provincial's actions climate action program to make the objectives visible for the territory” (Province of Flemish Brabant Environment Department, 2016).

Leuven’s roadmap 2025|2035|2050 (De Paep, Verachtert, & Van Reeth, 2019) underlined that continuous evaluation and optimization are crucial to ensure an effective implementation of the strategy. It elucidated that the city aims at monitoring and evaluating the achieved results, defining the stakeholders that have been engaged as well as the encountered barriers. Consequently, for each measure presented in the roadmap, indicators are defined, determining the information that allows assessing the concrete impact of this particular action. The collected data is to be included and systematically updated to the roadmap (De Paep, Verachtert, & Van Reeth, 2019).

Additionally, carbon emissions are monitored on a monthly and a yearly basis which supports the city’s initiative on reaching ‘climate neutrality by 2030 (Leuven municipal councilor representing the Green party, interview, 2020).

The city of Leuven presents on its official website statistical data including a selection of relevant environmental indicators. The data comes from registered databases and allows to build an improved understanding of the situation at a local scale. The themes covered by the city’s collected data include demography, the built environment and infrastructure (e.g., year of constructions, types of dwellings), urban transport (e.g., the share of residents relying on cars, public transport or bikes, state of cycle paths, number of parking spaces, etc.), nature, environment, and energy (e.g., the share of residents satisfied with green areas in the city), poverty, education, businesses, and health (Heyvaert & Jansen, 2018). It is however important to underline that these indicators allow determining the city’s progress in the area of sustainable development and climate neutrality rather than urban resilience and climate adaptation. Not to mention, the city’s roadmap to climate

neutrality avows that there is a need for more environmental knowledge and data specific to Leuven to monitor and evaluate the results and to optimize measures for climate transition (De Paep, Verachtert, & Van Reeth, 2019). As a case in point, no figures and data are available at a local level particularly on water quality, water consumption, and water losses in the distribution network. This information is rather available at a regional level. The situation makes it hard to develop a monitoring and evaluation at a local scale. As of 2020, a survey will be conducted on a two-yearly basis to collect and update the required data (De Paep, Verachtert, & Van Reeth, 2019).

The City of Leuven (2020) affirmed in its climate action plan (2020-2025) that the monitoring and evaluation of the progress to ensure a climate-neutral city is driven by a strategic cell. The latter, alongside the Sustainability Department together and the Data Management Department, monitors the situation through the “Futureproof Cities” app which assures the availability of data collected with different partners such as the region of Flanders, the organization Leuven 2030, and the KU Leuven (De Paep, Verachtert, & Van Reeth, 2019).

Futureproofed (n.d.) in its tool guide for municipalities and Cities asserted that the app allows for systematic documentation of programs and actions. It also allows to assess and evaluate the impact of policies during and after implementation. Furthermore, it provides a platform for the exchange of knowledge and experiences with other cities as a talk is organized twice a year bringing together the Futureproofed Cities community. It gives visibility to the measures implemented by member cities. Lastly, a team of experts offers its support and plans regular follow-up sessions to address bottlenecks (Futureproofed, n.d). Nonetheless, it is important to underline that this tool is focused on mitigation rather than adaptation.

“The result of urban climate policy is difficult to measure, as its impact is sometimes reflected after a long preparatory period and given many other factors are also decisive (regulation, financial aspects, policies other governments, ...)” asserted the city of Leuven (2020) its climate action plan (2020-2025) which included a comprehensive review of the 2013-2019 Leuven’s climate action plan carried out in spring 2018. The review underlined the changes in CO2 emissions over the past few years in different sectors including industry, mobility, energy, nature and agriculture, trade, and services, and at the scale of households. It also revealed the reduction of waste production due to circular economy initiatives, waste prevention policies, and projects. Additionally, it claimed that the share of green areas managed by the city increased from 220 hectares in 1998 to 314.9 hectares in 2019, and the area of neighborhood parks increased from 88.69 hectares in 2000 to 156.31 hectares in 2018.

The city of Leuven is working out a system where data is not only used to evaluate the policy but also to proactively steer it. For this purpose, it aims at setting up a systematic data collection and follow-up on projects via an analytical function evaluation method. Leuven’s climate action plan (2020-2025) highlighted that monitoring should be based on the most accurate and up-to-date data. A set of indicators are defined in the city’s climate action plan for each of the proposed measures and actions. “These indicators are drawn up and updated in consultation with various partners” asserted the city of Leuven (2020) in its climate action plan. It underlined that the results will be communicated via a public page (such as the Futureproofed Cities platform) to involve residents in climate policy and give access to information for anyone who wants to follow this

monitoring. This way the data can be used (by both city officials and citizens) to explore how certain actions or policies can be refined and adjusted.

The adaptation strategy indicators concretized by the climate's action plan (City of Leuven, 2020) include the number of residents reached through projects and initiatives, the area of greenery, the number of planet trees managed by the municipality, and the number of "green projects". The city monitors the increase in the area of forests, agroforestry, and the amount of carbon captured (to the extent of data availability). It also inspects overflow and flood frequencies, and the area of paved surfaces as well as the permeability ratio (hard surface/green surface ratio). Other quantitative indicators include the number of projects implemented to increase the permeability of surfaces as well as the quantity of recovered source water. It is however remarked that the climate action plan includes more indicators related to energy policies and sustainable transportation and agriculture systems and does not embrace qualitative adaptation indicators. The City of Leuven (2020) asserted in its climate action plan (2020-2025) that a 'core climate adaptation group' is responsible to monitor the progress of the adaptation policy plan and ensure its horizontal integration across different city services. The group is responsible to establish collaboration between various city actors and create synergies. The Department for Road and Water Management, the green service, the Sustainability service, and the Department for Space and Heritage are represented in this group, as well as the Leuven 2030 organization.

4.3.6 Understanding Success and Limiting Factors: The challenge and the need to accelerate adaptation efforts to reach the city's long-term objectives

Both progress reports (covering the periods of 2013-2015 and 2016-2017 respectively) developed by the Flemish Government to follow up on the implementation of the Flemish climate plan show that, in the region, most municipalities are taking climate change seriously and are already thoroughly considering how to deal with it. These reports give information about the level at which various climate measures are implemented in different policy domains.

In Flanders, the implementation of measures is the responsibility of the sector, and in particular the competent authority itself. It is therefore these bodies that, through the pilots, provide the texts for the Flemish progress report (Associate at the Flemish Environment Agency, interview, 2021). The Flemish government (2017) asserted in its progress report (2016-2017) that although cities and municipalities are the most important partners to the implementation of adaptation measures, they were until recently little involved in the policy.

The Flemish Environment Agency avowed in its drought and flooding plan (2019-2021) that the planned policy for water scarcity risk management is still in its infancy in the region given that the last extreme drought manifested itself more than 40 years ago. It underlined that the available information, data, and knowledge on water systems are still fragmented and spread over various platforms which makes access to it more complicated. More knowledge and experience are acquired to address the issue of floods as Flanders has been frequently confronted with flood damages (Associate at the Flemish Environment Agency, interview, 2021). Nonetheless, addressing flood issues seem more complex in cities and densely built-up surfaces which presents a serious challenge for municipalities and cities to give more space for the water to flow (VMM, 2019).

The provincial climate plan (the Province of Flemish Brabant Environment Department, 2016) highlighted that funding local climate policies remains a complicated task. Therefore, it urged the development of an optimum set of financial instruments that match this financing need. Likewise, Futureproofed (n.d.), a consultancy firm based in Leuven, asserted that the availability of cash flows to invest in climate measures is a major challenge.

Terrens, Haesevoets, & Nuyts (2011) underlined that one of the major logistic challenges faced by Flemish authorities is following the occurrence of environmental disasters due to the pressure on emergency resources (including services and people) as well as food provision and shelters for affected people.

The city of Leuven (2019) underlined in its vision memorandum (Leuven 2019-2024) that it welcomes every year around 1,000 new inhabitants and around 50,000 students from more than 170 nationalities. The growth of the city's population presents new challenges such as ensuring sustainable and viable development as well as affordable housing in green neighborhoods while preserving the openness of the space (City of Leuven, 2019).

According to local actors, one of the success factors allowing the city to place itself on the world map for climate action is the Leuven 2030 organization and the roadmap 2025 | 2035 | 2050 (Leuven municipal councilor representing the Green party, interview, 2020; Alderman in the board of mayor at the city of Leuven, interview, 2020). "The fact that the city has a scientifically based roadmap is very helpful and assures the basis for the implementation of adequate projects" (Leuven municipal councilor representing the Green party, interview, 2020). The city is proud of the local organization which assures a participatory approach as it believes in the importance of engaging various actors across the city, affirmed an Alderman in the board of mayor at the city of Leuven (interview, 2020). He nonetheless elucidated that, despite efforts to engage people, it remains a challenge to involve and bring together all the different interests in the city. For example, when the city is working on the topic of mobility and wants to reduce the number of parking spots in the city or makes some street pedestrians, some tension comes up from shop owners or other people who think the city is not reachable anymore (Leuven municipal councilor representing the Green party, interview, 2020; Alderman in the board of mayor at the city of Leuven, interview, 2020). The city is also confronted by the need to assure social climate justice as it is easier to involve the middle and upper class in the implementation of adaptation measures, but it is a great challenge to involve the people with low income, while "these are the most vulnerable population" asserted an alderman in the board of mayor at the city of Leuven (interview, 2020). He added that another challenge facing the city is the need to accelerate adaptation efforts as the issue of climate change is exacerbating.

To address barriers to implementation, the city is aiming on making an active contribution to the improvement of knowledge on the topic of climate change with the help of local experts and KU Leuven (De Paep, Verachtert, & Van Reeth, 2019). "The municipality and Leuven 2030 are working alongside the local university to address to bridge knowledge gaps" (Alderman in the board of mayor at the city of Leuven, interview, 2020).

4.3.7 Improving the Governance System in Place: The roadmap 2025|2035|2050 inspiring the development of the city's new climate plan

In the implementation of the Royal Decree of 16.02.2006 on Emergency and Response Plans, a risk analysis is carried out to prioritize hazards.

The federal contribution to the National Climate Change Adaptation Plan, adopted by the Belgian Council of Ministers (2016), asserted that at a national scale, emergency action plans have been established for floods and forest fires and channels have been developed to inform the population in the event of a crisis. In addition, a national platform has been developed for disaster risk reduction in 2016 (Sendai platform).

To ensure better preparedness for future natural hazards, a collection of information and experiences after the occurrence of incidents is ensured alongside a systemic collection of data on natural disasters, such as the EM-DAT (The international Disaster Database) developed by the Center for Disaster research on the epidemiology of disasters. The information management is developed across different parties involved in the planning for emergencies at municipal, provincial, regional, and national levels asserted the federal contribution to the National Climate Change Adaptation Plan (Belgian Council of Ministers, 2016).

An Alderman in the board of mayor (interview, 2020) explained that Leuven is not really exposed to major environmental disasters, especially in comparison to other cities that are coastal or that are facing acute environmental risks. Consequently, no contingency or emergency plans have been developed at a local scale to respond to risks that are linked to climate change (Alderman in the board of mayor at the city of Leuven, interview, 2020).

The MIRA report presenting climate impacts and projections on Flanders stated that “great uncertainties in future climate change should not be a reason to postpone adaptation to the changing climate” (Brouwers et al., 2015). It recommended considering future changes of climate in the update of policies and the design of new projects and plans. It also highlighted the importance of continuously adjusting climate projects based on new evolutions and insights in the light of climate change.

A new Flemish Climate Plan (VKP) has been approved by the regional government. It defined guidelines for climate policy for the years 2021-2030. A Flemish Adaptation Plan (VAP) (2021 – 2030) will be drawn up as part of the Flemish climate plan (2021 – 2030), building on the measures and results from the previous VAP (2013 – 2020) to increase the resilience of the region against the effects of climate change. The Flemish Environment Agency (VMM) (n.d.) also affirmed on its climate portal that some work is ongoing to map the vulnerability of the region to the impacts of climate change based on previously obtained results and further insights.

Moreover, following the drought of 2018, the Flemish Minister of Environment, Nature, and Agriculture commissioned the regional environment agency (VMM) to work out a drought and flood action plan (2019-2021). The latter shed the light on what has been done at a regional scale in the field of water management, as well as what is to be added to the implemented actions to improve the resilience of the territory and its adaptability to climate change. It adds to the river basin management plan (2016-2021) which was adopted by the Flemish government in 2015 and includes flood risk management plans but doesn't and elaborate on the topic of water scarcity.

Also, the structure of the action plan is aligned with the draft water policy document (2020-2025) which defines guidelines and objectives for sustainable water management.

A new river basin management plan is to be developed for the period 2022-2027 and will address important issues related to flood risk management and water scarcity and drought risks, asserted the VMM (2019) in its drought and flood action plan. The latter affirmed that remarks and suggestions regarding crisis management in the event of water scarcity and droughts are included in the ongoing Coordination Committee on Integrated Water Policy consultation.

La Rivière (2015) introduced the 3 vital pillars and that need to be included in the coming 10 years for successful Flemish flood management. These pillars are 'Avoidance, Awareness, and Assistance'. 'Avoidance' refers to the prevention of urban developments in flood-prone areas unless constructions are flood resistant. 'Awareness' includes educating and informing people and making them more resilient. And, 'Assistance' is providing help to people, before, during, and after flooding events (La Rivière, 2015).

The roadmap developed by 'Leuven 2030' has forward-thinking as it highlights for each program of action the measures to be implemented by 2025, 2035, and 2050. 'Leuven 2030' asserted on its online platform that the roadmap is a flexible trajectory that is to be updated based on new information from monitoring. This shows that the city is adopting an adaptive management approach to climate adaptation (Rijke et al., 2012; Marmorek et al., 2019).

In 2019 a team of "program facilitators" was established tasked with translating the city's climate neutral vision into concrete actions (Environmentalist and researcher at the KU Leuven, interview, 2021). The roadmap declared that the implementation of proposed measures is considered a learning process for both the city and other municipalities following Leuven's lead. It elucidated that the ambitions and methods that are contained in this Roadmap are a snapshot and to be revised bi-annually (De Paep, Verachtert, & Van Reeth, 2019). In that sense, the proposed roadmap is version 1.0 and is subject to change as additional research and pilot projects allowing for experimentation will pave the way towards ensuring climate neutrality (De Paep, Verachtert, & Van Reeth, 2019). The guidelines towards the city's climate neutrality stressed the importance of sharing knowledge. "Easily accessible information should be made available to anyone wanting to take action, but efforts should also target groups that are less inclined towards sustainability, to encourage them to act, too. Special attention will be devoted to young people, who represent the city's future." (De Paep, Verachtert, & Van Reeth, 2019).

To ensure an improved governance system, Leuven's roadmap (De Paep, Verachtert, & Van Reeth, 2019) asserted that it is important to organize regular meetings allowing for the sharing and exchange of experiences and results from both successful and unsuccessful measures. The city had the ambition to organize an annual Leuven 2030 Congress as of 2020, affirmed an Alderman in the board of mayor at the city of Leuven (interview, 2020). He elucidated that this congress intended to allow various stakeholders to develop an improved understanding of levers and barriers to adaptation which will be a basis for the rectification and the adjustment of the roadmap. However, the outbreak of the coronavirus affected the organization of such events bringing a large crowd together (Alderman in the board of mayor at the city of Leuven, interview, 2020).

The city of Leuven (2017) affirmed in its application to the European green leaf award that the climate action plans of the organizations which are part of the 'Leuven 2030' (including the municipality of Leuven) need to be updated every 3 years. Moreover, the Sustainable Energy Action Plan needs to be updated every 2 years according to the requirement of the Covenant of Mayors.

The city's climate action plan (2020-2025) introduced a concise assessment of the previous action plan (2013-2019). The assessment is however not thorough or conclusive, and it does not really introduce or elaborate on the impacts of climate change at a local scale (Environmentalist and researcher at the KU Leuven, interview, 2021).

The city of Leuven (2019) stressed in its vision memorandum (Leuven 2019-2024) that it is important to keep long-term consequences in mind in the field of policy. It also asserted that it views innovation and experimentation as key to addressing the issue of climate change and claimed its ambition to be a living laboratory testing different approaches. To grant innovation, the municipality in collaboration with Leuven 2030 will investigate new solutions through monitoring, data collection as well as the study of good practices and pilot projects. The vision memorandum (City of Leuven, 2019) distinctly stated that "data will guide policy and, in addition, opening up data (with respect for privacy) can also be an added value".

As stated in the city's vision memorandum (City of Leuven, 2019), Leuven is focused on ensuring a future-oriented strategy and has the ambition of becoming a climate-proof, sustainable, circular city in the coming decades and one of the most livable urban areas in Europe by 2030 (City of Leuven, 2019). A strategy is being worked out to turn Leuven into a circular city through the development of initiatives that focus on circular construction, the repair of networks, and the management of urban material flows. This strategy is expected to ensure a more resilient city with a high reliance on local resources. For example, in this case, rainwater is seen as a resource rather than wastewater, it can be collected and re-used to increase water supply" clarified an alderman in the board of mayor at the city of Leuven (interview, 2020).

4.2.8. Assessing the Urban Climate Adaptation Governance of Leuven

The collected data due to the review of various documents and the conduction of interviews with different key stakeholders in the city of Leuven (presented in sections 4.3.1 – 4.3.7) allowed to answer the set of 50 close-ended questions that were presented in the methodology (section 3.6.1) forming the adaptation governance index.

The application of the developed index to the city of Leuven showed that the latter has a moderate to favorable urban climate adaptation governance with a value of 7.8/10 (*refer to appendix III – table 14*), meaning that local actors are invested in increasing urban resilience and are experimenting with various adaption policies. However, further research, resources, or investments could be needed to boost adaptation efforts at a local scale.

The results presented in the figure below (*figure 38*) underline that the city of Leuven has put remarkable efforts in the areas of developing adaptation strategies, implicating and mobilizing actors, and understanding success and limiting factors to increase its urban resilience in the face of climate events. However, more efforts are needed in different areas such as the understanding

of impacts, the implementation of developed adaptation strategies as well as the amelioration of the monitoring and evaluation system to improve the adaptation governance system in place.

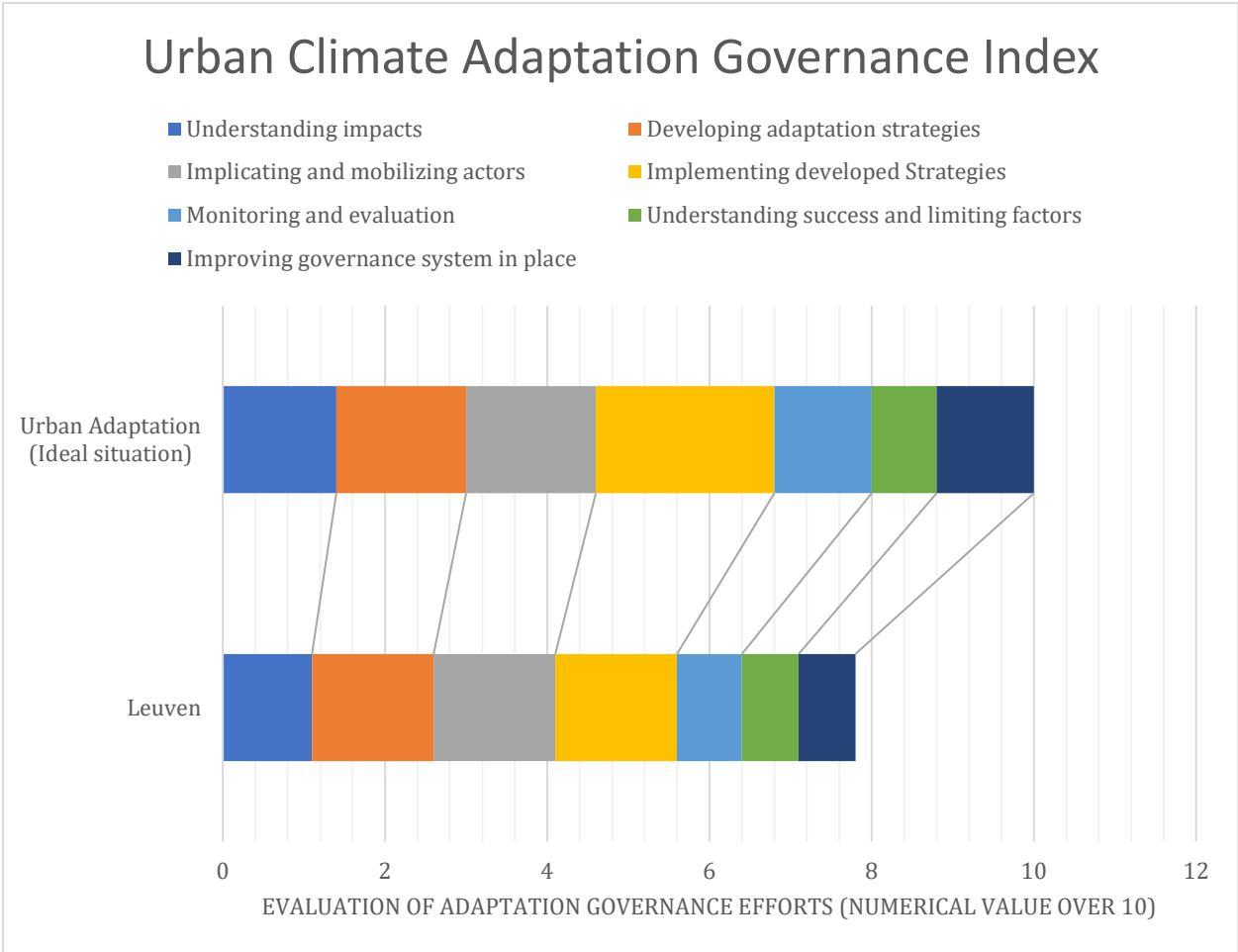


Figure 38 Visualization of the index score of the city of Leuven across various areas of climate adaptation governance.

The results (detailed in appendix III – table 14) demonstrate that Leuven could improve its urban climate adaptation governance approach by developing an improved understanding of the impacts of climate change on the city. There is more knowledge at a regional level than at a local scale and that the knowledge available at a local scale is relative to climate mitigation (i.e., the contribution of sectors to GHG emissions) rather than adaptation. Thus, the development of maps and impact assessments -particular to the city of Leuven- detailing the influences of climate change on various sectors as well as its socio-economic ramifications is crucial to increasing the city’s adaptive capacity.

The city is doing particularly well in the area of ‘development of adaptation strategies’ given that it has a climate action plan and a roadmap on the horizon 2025, 2035, and 2050. However, to improve its adaptation governance approach, the city could define its areas of priorities based on a mapping of vulnerabilities.

The implication and mobilization of actors through the Leuven 2030 organization and the collaboration of local authorities with experts and scientists at the KU Leuven have contributed to

increasing the city's adaptive capacity. Nevertheless, as deduced from the results, the city could boost the implementation of adaptation strategies by ensuring the availability of appropriate material and financial resources (e.g., crowdfunding initiatives, incentivizing climate investments, etc.). The city could also invest more in the development of big-scale infrastructure projects or transformative adaptation actions rather than small-scale initiatives to improve its adaptive capacity and increase its climate resilience.

The results indicate that the city could develop more thorough monitoring and evaluation system embracing both qualitative and quantitative indicators to develop an improved understanding of success and limiting factors. The long-term vision developed by the city and the flexibility of the roadmap to integrate new findings and insights have contributed to refining the city's climate adaptation governance approach. Nonetheless, Leuven could improve its adaptation governance system through updating existing vulnerability assessments to integrate new findings and insights, developing an improved understanding of long-term impacts of climate change based on projections, and developing new adaptation policies based on recent vulnerability assessments.

4.4 The case of Växjö, Sweden



Figure 39 The city of Växjö. Source: Google Maps, 2021.

The Swedish city of Växjö is examined to develop an understanding of climate governance in a mid-sized city of a European country that dedicates a high level of independencies and competencies to local municipalities.

To assure data collection published literature were reviewed including documents and articles developed by regional and local environmental agencies as well as national and international adaptation platforms. Environmental, climate and urban plans developed by the municipality of Växjö as well as communications on the city's official website were also examined. The data collection was also supported by articles and documents published by local and international press. For this case, and due to corona virus travel restrictions imposed in 2020 and 2021, a field visit was not possible. To adapt to the situation, online interviews were conducted with different actors including a Sustainability administrator at Växjö municipality (2020), a Swedish politician serving the Växjö Municipality (2020). Video calls were also conducted with an environmental strategist at Växjö municipality (2020), a member of the Växjö climate commission (2020), and an associate at the administrative board in Kronoberg County (2021).

The data collected through these interviews served to develop an improved understanding of the current circumstances at the city of Växjö as well as climate adaptation efforts at a local scale.

For this case study, a synthesis of the data collected, both primary and secondary, is presented below and organized based on the 7 areas of focus in the governance of climate adaptation which are introduced in the developed conceptual model (Section 3.4).

The municipality of Växjö, home to more than 91 000 inhabitants, consists of a combination of rural and urban living, with a densely built-up area bordered by countryside. It incorporates 13 clusters including the central city of Växjö which accommodates approximately 80% of the population (Tenje, 2018). Växjö is the industrial, cultural, and administrative center of Kronoberg

County, located in the center of the south of Sweden⁵⁴, 200 km away from Malmö. It is a university city housing the Linnaeus University, an important center of education and research in the region. Furthermore, the city's business environment is diverse as it accommodates many small and medium enterprises and is expecting to attract more businesses. Growing sectors include IT, service and tourism sector, building and construction, logistics, and forest and timber industry (Sustainability administrator at Växjö municipality, interview, 2020).

The city has the reputation of being 'the greenest city in Europe'. Forestry dominates the land use of the municipality as two-third of the area is covered with forests. Växjö has 27 'Natura 2000' zones and various protected sites which are within 5 km from the city center. Not to mention, the municipality has more than 200 lakes, of which seven are within a cycling distance from the city center affirmed a Swedish politician serving the Växjö Municipality (interview, 2020). He asserted that preserving the natural biodiversity and ensuring access to the public is among the Växjö's high priorities.

The city's social, economic, and environmental attractiveness invites new people to settle in. Växjö's population growth is remarkable and comparable to the growth of Sweden's major cities. Each year the population increases by 1000-1500 people (Tenje, 2018). By 2030, the city of Växjö is expected to be the home for 30,000 new residents announced ICLEI (2016) in its Växjö project city profile. If not well-managed, this could increase the pressure on the natural environment as new residential buildings will be constructed to accommodate the increase of residents.

Växjö is devoted to ensuring and enhancing the compactness of the city -despite the population growth- through limiting urban sprawl and minimizing land consumption to protect natural areas surrounding the city (Sustainability administrator at Växjö municipality, interview, 2020). As stated by ICLEI (2016) in its Växjö project city profile, the city hopes to be able to achieve compactness, through urban planning, speculative development, and management of land supply, to ensure efficient land use and reduce the need for using cars. It is also aiming at introducing mixed-used projects and buildings to ensure optimization and proximity within the neighborhood (ICLEI, 2016).

4.4.1 Understanding Impacts and Vulnerabilities: Developing a risk and vulnerability analysis at the scale of the city

In 2005, the Swedish Government appointed a 'Commission on Climate and Vulnerability' to develop an understanding of the socio-economic impacts of climate change on regional and local levels. The commission published a report in 2007 introducing the threats and opportunities in the light of this global phenomenon on the country. The report (Swedish Commission on Climate and Vulnerability, 2007) underlined that the temperatures tend to rise more in Scandinavia and Sweden than the global average. It expounded that in Sweden temperatures are expected to increase between 3 and 5 degrees Celsius by the 2080s considering the baseline period 1960-1990. Consequently, winters are expected to become milder, and summers are expected to become hotter. The commission's report asserted that a warmer climate could lead to an increase in the spread of infection as well as other effects on human health and could even lead to an increase in the rate of mortality. It also affirmed that precipitation patterns are expected to change as

⁵⁴ "Sweden is divided into 21 counties regionally and into 290 municipalities locally, each with an elected assembly or council" (Lukat, et al., 2016).

projections foresee an increase during winter, spring, and autumn in almost all the areas of Sweden and a decrease in summer, especially in the south of the country. It added that the water quality of lakes and watercourses is expected to deteriorate necessitating efforts to preserve drinking water of good quality. Not to mention, in the light of heavy rainfall events, the risks of landslides, erosions, and floods are expected to increase. The Swedish Commission on Climate and Vulnerability (2007) stated that climate change could also present some opportunities and benefits at a country scale, such as an increase in hydropower potential and a reduction of the need for heating.

In the government's budget proposal for 2011, the Swedish Meteorological and Hydrological Institute (SMHI) received a budget to establish a 'National knowledge Center for Climate Adaptation'. A climate adaptation portal⁵⁵ was also developed in collaboration with the SMHI to provide information.

The SMHI performed a regional analysis of climate change and flood risks in a future climate for the Kronoberg County. The results were conveyed in the report 'Regional Climate and Vulnerability Analysis Kronoberg County – Risk for floods and high flows' published in 2010. This report depicted climate variation based on evaporation rates, rainfall, and temperatures and presents 2050 and 2100 climate projections.

An associate at the administrative board in Kronoberg County (interview, 2021) clarified that national reports developed by the SMHI are interpreted regionally by the county administrative board. The county's climate analysis can be found on the administrative board's website⁵⁶. Maps, indexes, and figures are developed presenting the number of days with heat waves and seasonal variation in precipitation and temperature. The sectors that are impacted by climate change have been identified and presented in the regional action plan for climate adaptation (Van Meeningen, 2016) including governance, community planning, water, human health, agriculture, natural environment, and cultural heritage.

In 2011, Växjö conducted a risk and vulnerability analysis (RSA⁵⁷) highlighting the impacts of climate change at a local scale. The city used the regional climate analysis report developed by the Kronoberg county as a basis to develop its understanding of local impacts and set up a local climate adaptation plan (Environmental strategist at Växjö municipality, interview, 2020). The European Environment Agency (n.d.) communicated on its online platform (through the climate adapt initiative) the sectors that are affected by climate change in the city of Växjö including biodiversity, transport, water management, health, urban planning, and constructions.

To determine the municipality's vulnerability to climate change, 4 systems were analyzed and introduced by the Växjö commune (2013a) in its climate adaptation plan including (1) human health, (2) constructions and buildings, (3) technical supply systems and infrastructure, (4) natural environment, agriculture, and tourism. The conducted analysis demonstrated that:

(1) Warmer climate could have different impacts on various groups and could present both negative and positive effects on human health. For instance, as presented in the commune's

⁵⁵ Klimatanpassningsportalen.se.

⁵⁶ <https://www.lansstyrelsen.se/kronoberg/>.

⁵⁷ Risk- och sårbarhetsanalys.

adaptation plan (Växjö commune, 2013a), prolonged heat waves increase the risks of mortality particularly among susceptible groups such as people with chronic diseases and the elderly. Also, increased temperatures could be of inconvenience to allergic people as the pollen season could be prolonged. Not to mention, a warmer and wetter climate increases the risk of the spread of infections. On a more positive note, milder winters could decrease the number of cold-related mortalities (Växjö commune, 2013a).

(2) In 2011, the Swedish planning and building act introduced that climate aspects and risks should also be considered in the planning. The municipality is the one responsible to make an assessment determining the areas that are suitable for urban development, therefore risks such as floods, landslides, erosion need to be considered in urban planning. The municipality is aware that considering all climate-related issues at the earliest possible stage would minimize the costs of adaptation. The commune's adaptation plan (Växjö commune, 2013a) asserted that the location of buildings needs to be appropriate considering risks to human health and other hazards, also climate change needs to be considered when planning for construction.

(3) Växjö commune (2013a) asserted in its adaptation plan that it is important to analyze the consequences of climate change on infrastructure and technical supply systems to develop appropriate measures and limit the impacts. The area of technical supply systems and infrastructure includes services that are critical to society's progress such as electrical systems, roads, stormwater, drinking water, and sewage, ICT, among others. The challenges are often not new to the city, but climate change is likely to aggravate them.

(4) Växjö's adaptation plan (Växjö commune, 2013a) affirmed that climate change could have dramatic effects on biodiversity and the natural environment. It elaborated that agriculture and forestry are at an increased risk of damage due to diseases and insects from a more humid and warmer climate. The Växjö commune (2013a) affirmed in its adaptation plan that it is working to ensure that the landowners and workers in the agricultural sector are planting trees and crops suitable and resistant to future changes of climate and reducing the use of fertilizers as they could compromise the soil and water quality. It also clarified that some benefits could arise as a milder climate allow for a longer vegetation period and the plantation of new crops. Likewise, the tourism industry in the region is also likely to benefit due to more pleasant temperatures and weather.

The Växjö commune (2013a) indicated in its adaptation plan that the direct changes in temperatures, especially that it is happening a progressive way, may not sound very dramatic. It nevertheless clarified that climate change could have significant impacts on weather phenomena such as extreme heatwaves, increased evaporation, and heavy rainfalls.

The citizens of Växjö have a high level of awareness as environmental education is ensured in secondary schools (Dale, 2011; Saldert, 2015). The municipality conducts surveys bi-annually to determine the sustainability and environmental awareness of the citizens. The results of these surveys have proved that the participation rate of the citizens and their level of sustainability awareness is significantly increasing (Dale, 2011). "The behavior of citizens indicates the level of their climate awareness" stated a sustainability administrator at Växjö municipality (interview, 2020), adding, "if they sort waste for example or chose to take public transport, it means they are acting responsibly towards the environment". According to the European Commission (2018b) in its communication introducing Växjö as a winner of the European Green Leaf award, almost 90% of the city's household separate organic waste and 50% of all waste is digested, composted, or

recycled, not to mention, trips per capita via public transport have increased by 40% over the past decade.

Increased temperatures and UHI effect:

The Swedish Commission on Climate and Vulnerability (2007) asserted in its report on the threats and opportunities of climate change that, in the coming decades, in Sweden, temperatures during summer are expected to rise on average between 2 to 4 degrees, depending on the considered scenario.

Projections presented in the report also foresee an increase in the number of days with exceptionally high temperatures and a decrease in the number of extremely cold days. The report clarified that the situation would affect the need for cooling and heating; the latter is expected to drop, while the need for cooling is likely to upsurge. It elucidated that this would have direct consequences on energy consumption. In the case of Sweden, the situation is likely to entail savings on energy costs as the cost of cooling is not expected to surpass the value of savings made by reduced heating costs (Swedish Commission on Climate and Vulnerability, 2007).

The Växjö adaptation plan (Växjö commune, 2013a) highlighted that the increase in average temperatures would lead to milder winters. It asserted that the number of days with snow cover is likely to decrease by around 35 days per year as of 2050 and snow-free years could occur in the country. The Växjö commune is aware that cities are more exposed to heatwaves than their surroundings due to the UHI effect. This difference is attributed to the ability of building and mineralized surfaces to absorb and store heat. The local adaptation plan (Växjö commune, 2013a) clarified that ,in winter, the UHI effect reduces the need for heating buildings and ensuring the maintenance of roofs and roads (i.e., salting and snow removal). However, it asserted that in summer, the situation intensifies the discomfort of city residents as it could contribute to heat-related illnesses such as heat exhaustion, respiratory difficulties, and heat strokes. In this context, it is important to underline that “the Swedish people are generally better equipped for cold rather than warm weathers” (Sustainability administrator at Växjö municipality, interview, 2020), thus the importance of increasing adaptability and preparing for changing climate conditions.

Växjö commune (2013a) asserted in its adaptation plan that a new Geographic Information System (GIS) layer has been developed showing the amount of mineralized surface area per property. The development of this data allows identifying vulnerable areas from an urban heating perspective and the areas that could suffer from major problems with stormwater in the event of heavy rainfalls. The data presented in the map below (*figure 40*) shows that the Västra mark, Norremark, and Öster neighborhoods, as well as the Växjö’s city center, are the most vulnerable areas to urban heating and floods.

A sustainability administrator at Växjö municipality (interview, 2020) highlighted that this effect of climate change has only begun to surface in recent years. In 2018, Växjö was impacted by a heatwave and a really hot summer, this has led to a bigger discussion on urban heating and the measures needed to reduce its impacts particularly on schoolyards and elderly care centers. Such events allow raising the awareness of both citizens and local authorities on the direct impacts of climate change on the city (Sustainability administrator at Växjö municipality, interview, 2020).

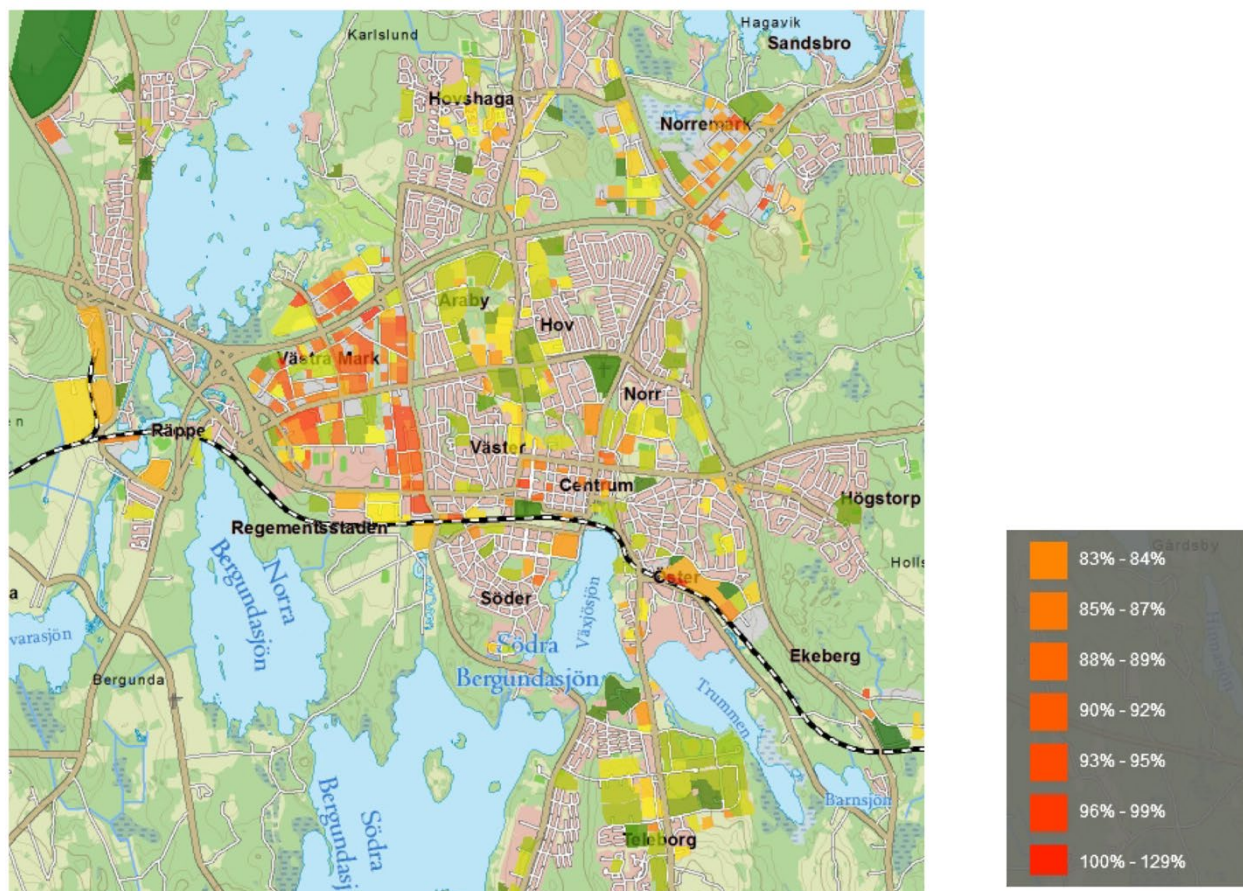


Figure 40 Proportion of paved area/property for properties larger than 4000sqm in Växjö. Source: Växjö commune, 2013a.

Floods and extreme weather conditions:

At the beginning of the 2000s, major floods affected Sweden such as the floods around Vänern lake. According to the Swedish Commission on Climate and Vulnerability (2007) and as introduced in its report on threats and opportunities in the light of climate change, floods pose risks on railways, roads, and constructions, as well as infrastructure services and could lead to lengthy power outage. Floods could also affect agriculture and industry sectors and could contaminate water sources which could increase the risk of disruption of drinking water supply.

The commission's report (2007) affirmed that the flood of sewer systems and surface water is a major problem in the country as around 6 million m² of building surface -at the proximity of watercourses- is at risk of inundating once every 100 years on average. The report also acknowledged that climate change is likely to increase the flood area and lead to more serious consequences. The increase of flows in watercourses, heavy precipitation, and the rise of groundwater levels could also intensify the risk of landslides which have previously caused casualties on many occasions in Sweden. The National Commission on Climate and Vulnerability (2007) also affirmed that more than 200.000 buildings are at proximity to water in regions where the risk of landslides is likely to surge and highlighted that "local conditions dictate where the risks will be greatest".

The Växjö commune (2013a) asserted in its adaptation plan that at a regional scale, the number of days with heavy rainfall (i.e., more than 10 mm/day) is expected to increase fivefold by 2050. A sustainability administrator at Växjö municipality (interview, 2020), highlighted that the heavy

rainfalls and floods are among the most prominent impacts of climate change on the city of Växjö. He clarified that “various parts of the central city have been built upon swampy and wet areas which makes them susceptible to pluvial floods”. The European Environment Agency (EEA, 2016b) in its report on stormwater management in Växjö affirmed that annual floods occurred due to rainwater and impacted the local infrastructure at the proximity of Linnégatan street, built on formerly existing stream. It elucidated that “streets were flooded for several days, and nearby buildings’ cellars were filled with stormwater causing high cleaning and reconstruction costs”. The EEA (2016b) asserted that at the beginning of 2000, the discussion about climate change and its local impacts was not very developed, elucidating that “the guideline was to develop effective measures to be prepared for 10-year rainfalls – not in the context of climate change but in a context of highly recurrent heavy rainfall events”.

Between 2000 and 2015, and according to the EEA’s (2016b) publication on stormwater management in Växjö, the total amount of rainfall in the city and the intensity increased by 15%. Projections foresee an additional surge in the intensity and frequency of heavy rainfall events in light of climate change. The Växjö commune (2013a) asserted in its adaptation plan that increased rainfall could lead to the flooding of basements and greater risks for moisture and mold damage, underlining the necessity of informing property owners about the importance of renovation and maintenance of buildings. It also declared that the increase in the intensity and frequency of rainfalls could lead to the wash-out of roads, the damage of bridges, erosions, and landslides as well as the congestion of stormwater networks and sewage systems. The city’s adaptation plan (Växjö commune, 2013a) asserted that the design of infrastructure systems should therefore be based on future and changes in water flow rather than historical rainfall. It elucidated that if stormwater and wastewater systems are not designed or upgraded based on climate projections and changes in water flows, water is likely to get contaminated with serious impacts on human health. The local adaptation plan (Växjö commune, 2013a) also shed the light on the fact that storms and heavy rainfalls could present some benefits as the energy content of the wind and the amount of rainfall affect the production of wind power and hydropower.

Droughts and water availability

The Swedish commission on climate and vulnerability (2007) stated in its report on climate threats and opportunities that “although there will be considerable consequences for the supply of drinking water, Sweden will be affected to a far lesser degree than many other countries”. It however clarified that the quality of raw water could be degraded which would need more articulated and adequate water treatment techniques, leading to increased costs.

The adaptation plan developed by the Växjö commune (2013a) asserted that the change of rainfall patterns as well as increase evaporation has impacts on the quality and the quantity of groundwater. It affirmed that despite an overall increase in rainfall over the year, there can still be dry periods, declaring that the calculations show that in the summer dry period could become up to 5 days longer per year by the end of the century, meanwhile, dry reason during autumn and spring could be 0-5 days shorter per year. The Växjö commune (2013a) elucidated in its adaptation plan that the increase of water temperature in lakes and streams is likely to lead to eutrophication and in consequence to the deterioration of water quality negatively affecting the flora and fauna

as well as residents in surrounding areas. It affirmed that many industries depend on a good access to water, and the deterioration of water quality could have indirect impacts of them.

Following the heatwave of 2018 and the hot summer temperatures, the agricultural landscape, and farmers in Växjö were affected by drought. Consequently, bans and regulations were imposed to regulate the use of groundwater (Environmental strategist at Växjö municipality, interview, 2020).

4.4.2 Developing Adaptation Strategies: Unanimous agreement of all political parties to ensure energy transition and environmental protection

Cappelletti et al. (2015) in a publication for the European association of local authorities in energy transition highlighted that Sweden follows a horizontal model of governance and does not operate on hierarchical principles. In the country, the concepts of horizontality and autonomy present strong values. The national government is aware that sustainable development and social progress are crucial for economic performance. Furthermore, society has concerns for the common good and a strong sense of commitment and responsibility to protect the environment (Cappelletti et al., 2015).

In its report on the threats and opportunities of climate change, the Swedish Commission on Climate and Vulnerability (2007) stated that despite uncertainties when it comes to future climate scenarios, it is necessary to adapt the country to the impacts of climate change. It asserted that regional administrative boards (counties) should be leading the coordination of climate adaptation efforts and recommended the formation of a new foundation for climate research and adaptation as well as the establishment of a climate adaptation panel at a regional scale to support municipalities. The Swedish climate commission (2007) asserted that the national environmental agency should be responsible to monitor, evaluate and report adaptation. It also asserted that sector authorities need to be assigned clearer adaptation responsibilities in their area of expertise.

No NAS was developed prior to 2018 in Sweden given that the responsibility to adapt and to develop action plans has been delegated to regional authorities affirmed an associate at the administrative board in Kronoberg County (interview, 2021). However, in 2018, the Swedish government adopted a NAS outlining coordination instruments and highlighting the importance of reviewing, monitoring, and evaluating adaptation measures.

Lukat et al. (2016) highlighted that “in Sweden, the development of regional adaptation plans coincided with the EU Adaptation Strategy”. The administrative boards of counties have significantly advanced on climate adaptation as each of them worked on region-specific action schemes (Lukat et al., 2016). The implementation responsibility is however passed on to municipality levels. County boards coordinate the work of municipalities, regional sector authorities, and businesses (Associate at the administrative board in Kronoberg County, interview, 2021). Helsing (2017) affirmed that “the County Administrative Boards act as a link between municipalities and the state and are commissioned to coordinate the regional adaptation work and give guidance to the municipalities”.

Kronoberg County follows a strategic methodology to horizontal and vertical integration of adaptation measures as presented in its action plan published in March 2016 (Lukat et al, 2016). The county invited and incited municipalities to sign the covenant of mayors for energy and climate asserted an associate at the administrative board in Kronoberg County (interview, 2021). The regional adaptation action plan (Van Meeningen, 2016) highlighted that not only it is necessary to adapt society to impacts that are felt, but also future climate change needs to be taken into account through conscious community building and planning. It clarified that adaptation means changes in functions, routines, processes, and perceptions of climate risks and affirmed that it could take place not only in physical and ecological systems but also in social practices. The regional adaptation plan serves as a guideline for regional actors and municipalities. The county is an advocate for developing information initiatives for key players, the public (including both adults and children), and real estate companies (Associate at the administrative board in Kronoberg County, interview, 2021). It also plans on specifying adaptation targets based on the EU scoreboard and evaluating them on a 2-yearly basis with the support of municipalities reporting to the covenant of mayors. This evaluation would allow for defining qualitative sub-targets (Associate at the administrative board in Kronoberg County, interview, 2021).

The Kronoberg adaptation action plan (Van Meeningen, 2016) proposed various measures at a national, regional, and local scale, and determined the responsible actors as well as the implementation timeframe. At a national level, it suggested appointing a ministry responsible for coordinating climate change issues. At a regional scale, it proposed taking a holistic approach to energy and climate issues by ensuring synergies, coordination, and joint organization. The action plan recommended calculating the cost of not adapting and strengthening cross-sectoral cooperation through developing working groups and joint projects (Van Meeningen, 2016).

Various measures for water management were also defined by the adaptation action plan (Van Meeningen, 2016) at a regional level such as assigning administration responsibilities, conducting a GIS analysis of important activities in flood-sensitive areas, preparing contingency plans for the flooding of watercourses, and extending supervision on water operations.

Additionally, the Kronoberg adaptation plan (Van Meeningen, 2016) suggested strategic measures that should be taken at a municipal scale, including, developing a local adaptation plan, or integrating adaptation measures into existing plans as well as joining the covenant of mayors.

It also emphasized the importance of appropriate zoning and land use based on vulnerability analysis taking into consideration future climate changes. Other measures were also proposed at a sub-regional level such as integrating climate adaptation into vulnerability and risk studies as well as municipal plans.

To address the direct and indirect impacts of climate change on health, regional and local measures were suggested in the Kronoberg adaptation plan (Van Meeningen, 2016) such as acclimating schools and new homes to future climate effects, arranging training and information meetings to relevant staff in schools and health care as well as informing the public.

As Sweden is a country with one of the most decentralized governance systems in the world, local municipalities have important responsibilities and assume a wide range of competencies asserted a Swedish politician serving the Väckjö Municipality (interview, 2020). He affirmed that “Mayors have great power and the ability to make changes at a local scale” and elucidated that local

municipalities are responsible for raising taxes and managing the budget and public spending from pensions to educations.

Moreover, since 1948, local governments in Sweden bore the responsibility to develop and ensure territorial planning (Clark, 2018). The municipality of Växjö challenged itself early on to become a fossil fuel city. Various external events, such as the eutrophication of the lakes in the 1960s and the oil crisis in the 1970s, aroused the interest of local officials in environmental and energy management and marked the beginning of the transition process (Cappelletti et al., 2015). To restore the water quality and find alternative energy sources, the city started to collaborate with environmental NGOs and initiated an exchange between political, citizen, socio-cultural, and economic actors (Cappelletti et al., 2015). In response to the eutrophication, the municipality integrated a program to combat this issue in the local urban plan. The success of the program was proof that the protection of the environment is an important factor of development for the city (Cappelletti et al., 2015). Moreover, following the 70s oil shocks and the increase in prices of fossil fuels, the municipal energy company made a shift to biomass to limit its dependency on petroleum and power the district heating system. This shift proved to have positive impacts on the local economy and allowed for the creation of new jobs. The success of these projects encouraged the city to adopt other environmental projects (Cappelletti et al., 2015).

Local governments in Sweden play a crucial role in climate adaptation as they have the responsibility to assure the functioning of energy and waste services, water, and wastewater plants as well as hospitals and care facilities (Swedish politician serving the Växjö Municipality, interview, 2020). The Växjö adaptation plan (Växjö commune, 2013a) underlined that the collaboration between various actors and administration is necessary as the issue touches on different areas and businesses.

In the city, the politicians have a high level of environmental awareness and have been addressing related issues for over 35 years (Member of the Växjö climate commission, interview, 2020). In 1991, all political parties in Växjö unanimously agreed that energy transition, as well as environmental protection, is crucial, asserted a Swedish politician serving the Växjö Municipality (interview, 2020). He confirmed that in 1993, the city developed its environmental policy and 2 years later it took the decision to eliminate the use of fossil fuels. For this purpose, the municipality started to cooperate with the biggest environmental NGO in Sweden to develop an improved understanding of climate and environmental issues (Member of the Växjö climate commission, interview, 2020). In 1999, the municipality prepared its local agenda 21. In 2006, the city council of Växjö decided to replace the environmental strategy and local agenda 21 approach with an environmental program that includes long-term as well as measurable and quantifiable targets proclaimed ICLEI (2016) in its Växjö project city profile. The following year, in 2007, Växjö adopted the logo “the greenest city in Europe” after it has received several awards and used ‘sustainable development’ as a way to brand and identify the city (Saldert, 2015). “The municipality has the aim of leading in environmental action and wants to set an example for other cities” elucidated a sustainability administrator at Växjö municipality (interview, 2020). However, as asserted by the Växjö commune (2013a) in its adaptation plan, up until 2011, governance efforts were mostly focused on reducing the city’s impacts on the environment rather than increasing the resilience of the territory to the impacts of climate change.

In 2011, the city of Växjö conducted the risk and vulnerability analysis (RSA) determining the effects of climate change at a local scale. In 2011-2012, the municipality participated in the EU

CLIPART⁵⁸ project. Its purpose was to collect and examine existing knowledge on energy and climate strategies and to develop guidelines for climate adaptation at a local scale (Helsing, 2017). This allowed establishing a general process for climate plans. Given that the local government has been working to address climate and energy goals for decades, it was easier to “add another layer” to these efforts and pay more attention to developing an adaptation plan, asserted a Swedish politician serving the Växjö Municipality (interview, 2020). He expounded that the RSA clarified the impacts of climate change at a local scale and the municipality was aware of the importance of taking action to adapt the territory to climate change. A member of the Växjö climate commission (interview, 2020) highlighted that “key actors and politicians in Växjö are aware of the necessity to adapt to climate change because even if the city is becoming climate neutral an entire world around us is not, so we will be impacted”. The municipality of Växjö also believes that developing a “climate-proof municipality” allows to increase the attractiveness of the city and strengthens the position of the city as “the greenest city in Europe” (Environmental strategist at Växjö municipality, interview, 2020). Consequently, a climate adaptation plan was developed in 2013 (Växjö commune, 2013a). The plan was set with the objective to limit the costs and the negative effects of climate change on municipal operations and to identify new opportunities. The same year, the ‘Green structure Strategy’ (Växjö commune, 2013b) was also established defining the functions and qualities of the green environment and giving a vision on how to sustain green areas as the city expands.

In 2014, The city updated its environmental program replacing the previous program from 2010 and re-instated its commitment and set the target to become fossil-fuel-free by 2030 asserted ICLEI (2016) in its Växjö project city profile. It further elaborated that “Växjö is the first local government body in the world to have taken such strong and decisive measures against fossil fuels” (ICLEI, 2016).

The city’s climate adaptation plan (Växjö commune, 2013a) asserted that it has the objective to identify the areas that require more focus and to integrate climate adaptation within the municipality’s processes as well as the activities of all sectors and individuals to ensure sustainable development.

Växjö’s adaptation plan (Växjö commune, 2013a) proposed possible measures to address the issue of floods, water availability, increased temperatures, and the UHI effect. It also suggested a series of measures to address the vulnerability of the electric system, to ensure the resilience of constructions and the built environment to climate change, to protect from landslides and erosion, and to address the impacts of climate change on human health (*refer to appendix II – table 10*).

The Växjö municipality, is, according to the Swedish Environmental Research Institute, among the municipalities that have remarkable adaptation efforts (Lukat et al., 2016). The adaptation plan developed by the Växjö commune (2013a) organizes the measures to be taken based on 3 levels of priority.

The most urgent measures are the ones to address existing major problems where work or improvements are needed immediately. These measures, as highlighted by the local adaptation plan (Växjö commune, 2013a), include ensuring the protection of vulnerable groups such as the

⁵⁸ The CLIPART sub-project aims at providing tools and guidelines to support local and regional authorities in planning and implementation of a climate policy.

elderly, children, and the ones with serious diseases as well as developing the resilience of the city towards stormwater and urban heating through the implementation of the green structure program.

The measures of medium urgency are the ones that need to be taken in the near future to address minor problems that exist today but that are likely to escalate based on projection models. These measures, according to the Växjö commune (2013a), include establishing training programs, awareness campaigns, identifying risks related to landslides and the availability of clean water, investigating opportunities that may arise, and developing inventory status on existing construction.

The least urgent measures are the ones addressing future expected effects. These measures, as underlined in the city's adaptation plan (Växjö commune, 2013a), include follow-ups and improved monitoring as well as developing further research on the choice of tree species to be implemented in urban environments (from a natural environment and health perspective).

The city's green strategy (Växjö commune, 2013b) articulated that the green environment increases the resilience of cities to climate change, affirming that "green areas absorb and purify rain off, enhance the quality of the air in the city and act as a buffer against strong temperature fluctuations... Green areas also lessen the effects of flooding on the drainage system". The strategy underlined the importance of including a robust green infrastructure within the context of the city planning process. It also asserted that green areas need to be retained in flood risk zones and additional green areas need to be developed in the city center and other parts of the city to complement the existing green structure from a climate perspective.

The green strategy (Växjö commune, 2013b) classifies green areas into five functions: recreation and outdoor activity, urban agriculture, climate mitigation, biodiversity as well as cultural aspects and identity. It defines how these functions can be further developed and be synergized and are considered as a tool for the future development of the city as it provides guidelines for the maintenance of existing green areas and the development of new ones as the city expands.

The strategy supports the commune's ambition of being the 'greenest city in Europe.

People's need for parks, nature, and recreational areas are intertwined with the commune's long-term responsibility to ensure sustainable development, which takes the issues of climate change into account (sustainability administrator at Växjö municipality, interview, 2020).

The green strategy (Växjö commune, 2013b) is set for the city of Växjö and its surroundings regardless of ownership (i.e., private/public properties).

Through the strategy, the commune presents its ambition of ensuring that all residents are within 50 meters from a small green area providing shade and a small children's play, within 300 meters from a park with a surface of at least 1 hectare, and within 800 meters from a large nature area (Växjö commune, 2013b). It asserts that this is crucial as the accessibility to parks, recreation, and nature areas contribute to improving the overall wellbeing of citizens as it stimulates movement and active social life. The Växjö commune stresses through its green strategy the importance of cultivation and urban agriculture. It asserted that "existing cultivated land and pastures should be retained as far possible, as the city is further developed through strategic planning. Furthermore, space should be allocated for cultivation and pastures in different scales as the city expands." (Växjö commune, 2013b).

In its updated environmental program, the city of Växjö (2014) presented measurable targets to be implemented by 2020 as part of the ‘vision 2030’ for the greenest city in Europe. These targets are related to the consumption of products and resources, waste production, water management, nature management, air and noise pollution, the reduction of climate impacts, sustainable energy production, and transportation. The program (City of Växjö, 2014) emphasized the importance of green and blue infrastructure systems and considers them as the city’s greatest assets. In 2017, the municipality proposed measures to increase the share of greenery in the industrial zone and limit the negative impacts of climate change such as urban heating and floods asserted a sustainability administrator at Växjö municipality (interview, 2020). He affirmed that the city has a long-term vision to adapting and greening the city. According to a member of the Växjö climate commission (interview, 2020), “all the political parties agreed that no matter who is running for office, environmental actions are a high priority and therefore targets last longer than elections”.

The city developed a new adaptation plan in 2021, building on the previous one developed in 2013. An environmental strategist at Växjö municipality (interview, 2021) however affirmed that the newly developed adaptation plan does not specify exact targets and deadlines because the implementation of measures depends on the budget of the municipality which varies from year to year. “This leaves room for the flexibility of approach in the governance of climate adaptation, but it could also lead to confusion and a risk of inaction if actors were not well informed on their role in climate adaptation as well as the measures to be implemented” (Sustainability administrator at Växjö municipality, interview, 2021).

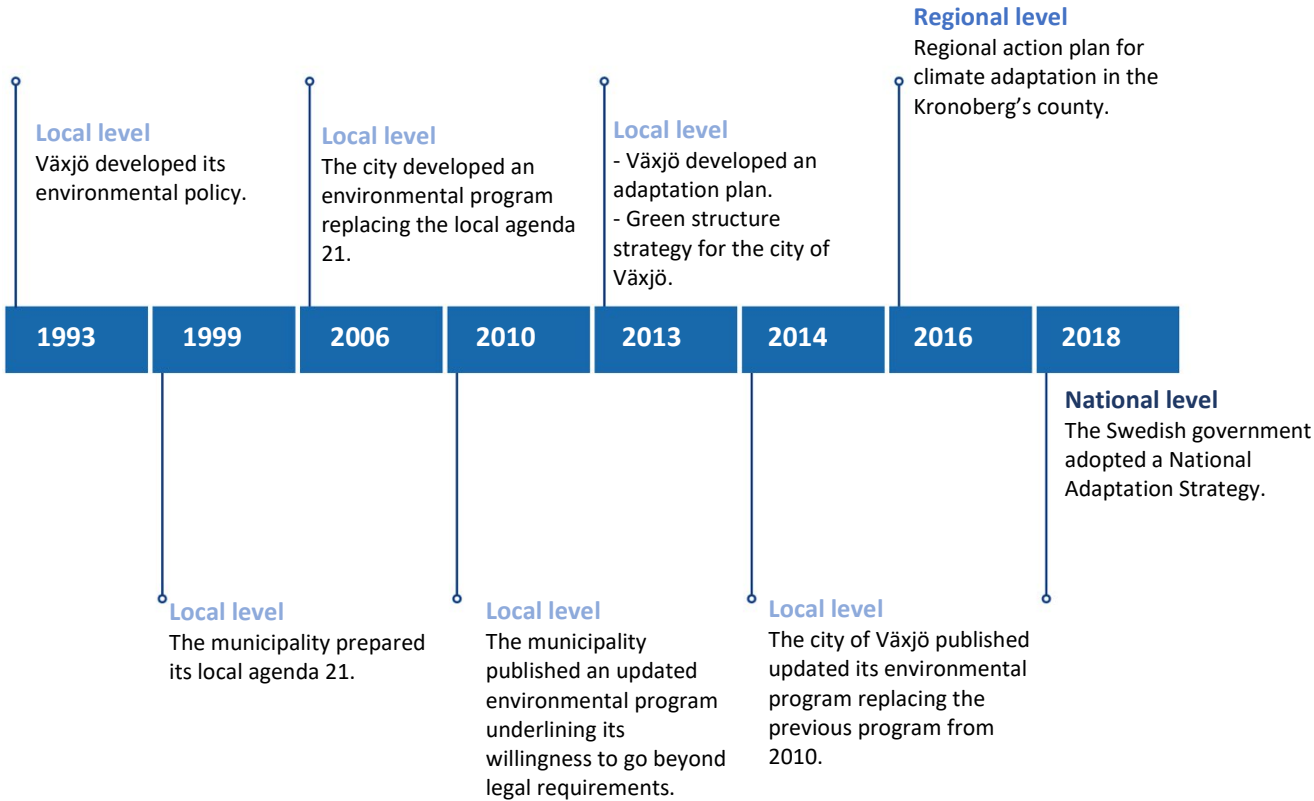


Figure 41 Timeline of strategy development at a national, regional, and local scale serving climate adaptation in Växjö.

The illustration above (*figure 41*) presenting the timeline of strategy development at various levels of governance shows that the municipality of Växjö has been committed to taking environmental action for over 3 decades. The commune has developed an adaptation plan at a local scale before a strategy or a plan was developed at a regional or national level. Efforts at a local scale seem to be dominating the efforts taken at supra-municipal levels. This demonstrates that the city is a pioneer in environmental and climate policies and underlines the willingness of the local authorities and their commitment to take necessary action at a local scale. This case illustrates the an example featuring a bottom-up approach to climate adaptation.

4.4.3 Implicating and Mobilizing Actors: Organizing roundtable discussions & including environmental issues in the curriculum of secondary schools to influence the behavior of younger generations

The Swedish climate adaptation portal⁵⁹ developed to make climate knowledge public was established as a result of a collaboration between the Swedish environmental protection agency, the Swedish Meteorological and Hydrological Institute (SMHI), the national housing agency, the Swedish social security and emergency preparedness, the national energy agency, the national geotechnical institute, the Swedish national food agency, the national board of agriculture, the national forest agency, the Swedish Geological survey and the national cultural heritage department. This underlines the importance of collaboration among various key stakeholders - having different perspectives and representing various sectors- to produce and dissipate climate knowledge and tackle this global issue at a national scale.

The regional adaptation plan (Van Meeningen, 2016) emphasized that virtually all sectors are impacted by climate change, thus, asserted that to manage risks and seize opportunities the distribution of responsibilities as well as cooperation among actors is necessary. Accordingly, for each of the proposed measures in this plan, actors that are responsible for initiating and implementing the proposed measures are defined. The regional adaptation plan highlights that no ministry is responsible for managing and coordinating climate change and suggests assigning responsible actors at a national level in charge of coordinating climate issues (Van Meeningen, 2016).

An associate at the administrative board in Kronoberg (interview, 2021) asserted that the county board organized municipal visits to assure working at proximity with local municipalities. The purpose of these visits was to compile climate adaptation work and to define measures as well as deficiencies in efforts and use that as a basis for the development of the regional action plan. Other regional actors also gave their views on measures that are needed for the ongoing adaptation work (Van Meeningen, 2016).

In 1995, the municipality of Växjö collaborated with the Swedish Society for Nature Conservation (SSNC) to guide its environmental actions. As part of this cooperation, various training and seminars were organized allowing for a dialogue between elected officials, municipal staff, and the SSNC. The business sector, citizens, and local NGOs were invited to participate and take part in this dialogue through roundtable debates and public meetings as they are considered responsible

⁵⁹ Klimatanpassningsportalen.se.

parties (Saldert, 2015). These meetings did not have the sole purpose of raising awareness and disseminating information to citizens and organizations but were also a way to retrieve information and develop an improved understanding of local circumstances asserted a Swedish politician serving the Växjö Municipality (interview, 2020). The exchanges and active participation of all actors were the basis for the development of the local agenda 21 (Cappelletti et al., 2005). The draft of the strategy was communicated with companies and NGOs which were invited to give their opinion and feedback before finalizing it (Saldert, 2015).

Following the municipality's political decision to become a fossil-fuel-free energy city by 2030, a Växjö climate commission was established bringing together key public and private actors to determine areas of action (Van Staden & Musco, 2010). However, a member of the Växjö climate commission (2020) clarified in an interview that this commission is focused on mitigation actions and is not responsible for determining adaptation targets as well.

In 1997, the Swedish government announced the creation of an investment fund with 600 million euros for environmental protection (Cappelletti et al., 2015). Local governments can apply for these funds by presenting a Local Investment plan. The latter can include projects carried out by private actors, NGOs, or the municipal administration. In Växjö, the local investment plan offered a unifying work environment as it allowed to mobilize key stakeholders from different sectors around thematic debates to prioritize actions (Environmental strategist at Växjö municipality, interview, 2020).

The private sector is also involved in developing responsible business practices to achieve competitiveness. Every year, a call for projects is issued, bringing together various actors to create innovative projects, to renew the funding requests to the European Commission and the national government (Cappelletti et al., 2015). An environmental strategist at Växjö municipality (interview, 2020) affirmed that the private sector is rather implicated in energy management strategies and sustainable business practices. He however elaborated that in the area of adaptation, the contribution of the private sector is still at its early stages, explaining that the municipality is aiming at improving the participation of various workers in the business sector. The municipality is a key actor and its technical department, as well as the executive committee, are the main departments that are concerned with climate and environmental issues. They identify structures that are in the best position to act based on a social or economic subject. For instance, to influence citizens' behavior, the education sectors and organizations are particularly entrusted (Cappelletti et al., 2015).

In the definition of its adaptation plan, the municipality makes sure to take into consideration the knowledge produced by experts and universities (Environmental strategist at Växjö municipality, interview, 2020; Member of the Växjö climate commission, interview, 2020). It works closely with regional and national authorities and collaborates with the Linnaeus University to develop its knowledge on the impacts of climate change and respective climate solutions asserted a sustainability administrator at Växjö municipality (interview, 2020). He however clarified that the city's work with the university is more elaborate on topics relating to sustainable buildings and renewable energy rather than water management or climate adaptation.

The city of Växjö is involved in national and international city networks allowing for the exchange of knowledge and expertise such as Klimatkommunerna⁶⁰, ICLEI, Union of the Baltic Cities and Energy Cities (Cappelletti et al., 2015). The municipality is among the first European local governments to sign the Covenant of Mayors and commit to developing energy and climate initiatives. It has been a part of this coalition since 2008 (Helsing, 2017).

Moreover, Växjö paired with the Canadian city of Burlington through the International Urban Cooperation program to collaborate on the development of an ecosystem approach to urban planning. Webinars and workshops were organized between both cities deliberating topics such as community engagement, stormwater management, the transition towards fossil-free cities, and infrastructure planning. The international project director highlighted that the exchange was fruitful as tangible progress was seen (Birnbaum, 2020). As a case in point, a technical expert from Burlington came to Växjö to share his knowledge on the topic of lake restoration. The Växjö staff, not only benefited from their Canadian counterparts for offering a peer review on the city's stormwater and lakes management plan but also benefited from their expertise to develop a green infrastructure plan for the Västra Mark neighborhood (Birnbaum, 2020).

A project group was established with the overall responsibility of developing the adaptation plan in the city. The group included a representative from the planning office, the technical administration, the emergency services, the city building office, the health and environment protection office, the care administration, and the city's energy group (Helsing, 2017). To draft the adaptation plan (Växjö commune, 2013a) for the city of Växjö, an information meeting was held for politicians and municipal officials, in which the county administrative board presented the impacts of climate change on society and emphasized the importance of coordination. Participants discussed the probable impacts of climate change on different municipal activities and proposed measures. The latter were then compiled and prioritized, and responsible administrations were appointed for each measure (Member of the Växjö climate commission, interview, 2020).

The Växjö adaptation plan (Växjö commune, 2013a) presented for each measure the party that is responsible for implementing it including the technical committee, environmental and health committee, schools and childcare, corporate boards, workers and developers in the construction field, workers in the tourism industry, the federal emergency unit, the municipality among others. A sustainability administrator at Växjö municipality (interview, 2020) explained that in practice some actors still don't know how to act on adaptation. He elucidated that there is no person responsible for assuring the coordination of adaptation efforts among various actors once the definition of the action plan is done. The coordination is limited to the development of the adaptation plan, but no one bears the responsibility to follow up and coordinate the implementation of measures (sustainability administrator at Växjö municipality, interview, 2020).

The city of Växjö collaborated with the national committee on climate change to initiate environmental projects. It is also trying to support government agencies, organizations, businesses, and residents to limit their ecological impacts. It is involving these actors through raising awareness and consulting with them (Saldert, 2015). The Växjö commune (2021) presented

⁶⁰ Klimatkommunerna is an association for municipalities, county councils and regions that work actively with local climate work.

in a communication on its online platform that its decisions are dependent on having contact with various stakeholders. For instance, approximately 2,000 residents, organizations, and companies have participated in dialogues about Växjö municipality's future to update the municipality's general sustainability plan (Växjö commune, 2021).

The municipality is not just focusing on implementing laws and regulations but is leaning more towards influencing the attitude of people instead (Saldert, 2015). Environmental issues have been included in the curriculum of secondary schools to influence the behavior of the younger generation (Saldert, 2015). Additionally, the commune holds regular information meetings to disseminate knowledge and has clearly outlined its goal and ambition to continue to raise the awareness of its citizens and employees. Each year, at the end of March, the city of Växjö celebrates annually the "Earth Week", a prolonged version of "earth hour". The city adopts this event as an opportunity to raise climate awareness by organizing dialogues and events (e.g., seminars, exhibitions, concerts) with NGOs, companies, and citizens (Member of the Växjö climate commission, interview, 2020).

4.4.4 Implementing Developed Strategies: Finding opportunities in the renovation of neighborhoods and the development of new city districts

The city is investing in the development of various environmental measures. Public servants from various departments are responsible to ensure the execution of adaptation projects (Environmental strategist at Växjö municipality, interview, 2020). As the Swedish governance system is among the most decentralized in Europe, local municipalities have important financial resources allowing for the enactment of adaptation actions asserted a Swedish politician serving the Växjö Municipality (interview, 2020). He highlighted that approximately three fourth of public money is collected at a local scale (e.g., taxes on salaries are collected by the municipality.) "This gives local governments the power and the responsibility to make changes" (Swedish politician serving the Växjö Municipality, interview, 2020).



Figure 42 The Linnaeus Canal, functioning as a storm water container, before and after a rainfall event. Source: EEA, 2016b.

An environmental strategist at Växjö municipality (interview, 2020) affirmed that the central parts of the city of Växjö are vulnerable to weather events and often flood during heavy rainfalls. He

elucidated that over the past decades, the city of Växjö has implemented various measures to limit the risks of flooding due to cloudbursts.

As a case in point, towards the end of the 1990s, the city began to re-open the Linnaeus canal in Lennagatan to prevent the flooding of streets and the surrounding areas. When the project was conceived, climate change wasn't particularly a concern, but the measure was taken in the context of frequent heavy rainfall events asserted an environmental strategist at Växjö municipality (interview, 2020). He added, nonetheless, that the construction of the canal allowed protecting the city from floods and is expected to protect, at least in part, the city from future floods that are likely to increase in the light of climate change (figure 42).

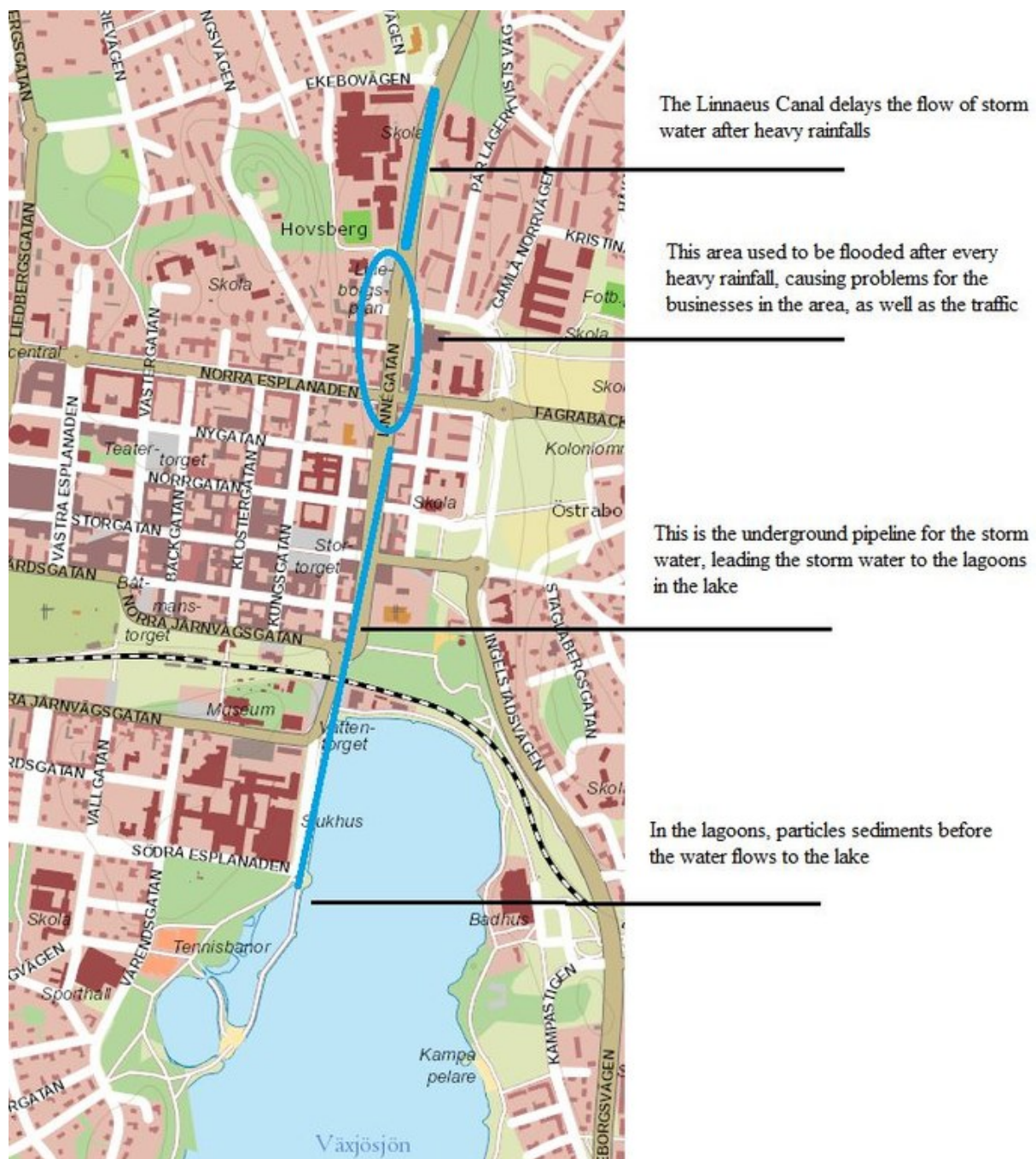


Figure 43 The Linnaeus Canal limiting the risks of floods. Source: EEA, 2016b.

The project took 3 years to complete (1998-2001) and has a life expectancy of 100 years. It cost around 2 million euros, the Swedish government, as well as the local Swedish financing program for sustainable development, covered 15% of this cost and the rest was financed by the city's technical department (EEA, 2016b). The project proved to be a success as after its construction, floods didn't occur with the same frequency and severity. According to the EEA's (2016b) publication on stormwater management in Växjö, "since the canal was built, there has only been one severe flood in August 2014". The EEA (2016b) elucidated that the canal functions as a stormwater container where the water is stored, conducted through underground pipelines, and released to sedimentation lagoons before reaching the Växjö lake. It explained that the sedimentation lagoons allow preventing the increase in the levels of particles, heavy metals, and nutrients of stormwater (*figure 43*). The project also had some co-benefits, for instance, it ensured increased traffic safety in the neighborhood. Moreover, the open water body in the city freshens the atmosphere and improves the esthetics of the city and is proof that adaptation measures could blend with the city's landscape and enhance the urban design (Environmental strategist at Växjö municipality, interview, 2020). The experience gained with the canal project provides a good example to develop integrate stormwater solutions allowing to take future climate correspondent actions (EEA, 2016b).

Other measures were also implemented to limit the risks of flooding due to cloudbursts (Sustainability administrator at Växjö municipality, interview, 2020). For instance, retention ponds for surface runoff have been constructed both under and over the ground in the city to avoid the flooding of cellars and houses. A concrete reservoir was erected under a parking surface to reduce the pressure on the drainage system and football pitch was designed to function as a retention pond. When the rate of flow is high in the surface run-off drains, the water is directed towards the pitch before then going down the drains when they can accept more water. Both projects were funded by the Växjö municipality and cost around 3 7530 000 SEK (approx. 3 452 700 Euros) as proclaimed on the Swedish portal for climate adaptation.

Furthermore, to protect the city from flooding, Växjö planned on building lagoons acting as dams next to the Lake. After the plans were made public to all concerned parties, environmental NGOs and citizens opposed them. Roundtable discussions with the interested parties including the municipality then allowed to modify the plan and build lagoons in the lake and keep the park untouched, asserted EEA's (2016b) in its publication on stormwater management in Växjö.

A sustainability administrator at Växjö municipality (interview, 2020) affirmed that the investments in integrated stormwater technologies have proved to be successful over the years. The municipality of Växjö has implemented various measures to adapt its stormwater system to cloudbursts and heavy rains. Nevertheless, in the summer of 2014, heavy rainfall events caused major floods and damages in the main parts of central Växjö, proving that the existing system is vulnerable and underlining the need for further measures to increase its resilience. Additionally, based on developed forecasts and modeling, the work needs to be developed and intensified since the existing network will be congested (Environmental strategist at Växjö municipality, interview, 2020).

To assure the availability of clean water, a restoration program has drastically improved the quality of lake waters since the 1970s asserted to the European Commission (2018b) in a communication introducing Växjö as a winner of the European Green Leaf award. It clarified that the stormwater

management program allowed to maintain the quality of water, adding that modern treatment facilities have been used to treat wastewater capturing nutrients from the resulting sludge and re-using them in agriculture.

To ensure climate neutrality, Växjö is renovating and upgrading the insulation of old buildings. A press article (Doyle, 2018) communicated that the city is relying on passive-homes building techniques to maximize energy efficiency. However, these approaches have co-benefits and allow to adapt constructions to changes of climate through improving comfort level for the inhabitants in times of extreme temperatures.

Växjö is encouraging urban agriculture and has cooperated with a social company to develop this practice. The Ekobacken (the “Ecological Hill”) is a central urban farming area in Växjö where organic vegetables are planted including sunflowers, tomatoes, pumpkins, and squash (Doyle, 2018). The cultivation land is owned and managed by the municipality. It is open and accessible for everyone to enjoy the environment and shop for vegetables. The cultivation has been KRAV certified since 2015, a Swedish label with additional requirements to EU-organic representing social responsibility, good health, good animal welfare, and environmental quality (Doyle, 2018). This initiative not only allows to increase the share of greenery within the city but also brings residents closer to one another, strengthening the sense of community, which is necessary to improve social resilience (Golden, 2013).

The city of Växjö is encouraging its citizens to change their habits and take part in the implementation of adaptation measures through awareness-raising campaigns and the development of financial incentives and disincentives. For instance, in 2007, in celebration of the World Environmental Day, the citizens of Växjö were incited to make environmental commitments that are related to various issues including waste management, resource use, consumption, and transportation. This initiative was implemented to raise the awareness of the public, encourage sustainable behaviors, and emphasize the role of citizens in addressing the issue. More than 500 persons attended the event that was organized in the city center and half of the attendees signed environmental commitments (Union of the Baltic Cities, 2009).

In Växjö, citizens must pay their water and sewers taxes based on the permeability of their gardens, affirmed a member of the climate commission (interview, 2020). He expounded that the municipality calculates the percentage of hard-sealed area in each garden including the roof and pavements. The higher the percentage of sealed area, the higher the taxes; this incites people to reduce the area of mineralized surfaces and increase the share of greenery.

The municipality of Växjö cooperated with experts from AFRY, an international design-engineering and advisory company, as well as experts from the academic world for the development of Bäckaslöv, a new city district which was a former military area. The project, offering commerce, schools, and housing, is seen as an opportunity to ensure the sustainable development of the constantly growing city (AFRY, n.d.). The initial drawings for the project included a traditional design with a road for the cars and sidewalks. However, the landscape architect at the city of Växjö proposed “focusing on people in the design rather than starting from the idea that cars should dominate” (AFRY, n.d.). In response, AFRY collaborated with the municipality and gathered more than 30 experts to take better account of the environment and people in the city. Consequently,

the traditional street plan was substituted by an asymmetric esplanade prioritizing social places and greenery in the streetscape. Various tree species were selected in consultation with experts at the Swedish University of Agricultural Sciences to ensure biodiversity and improve the soil's capacity to retain water and store CO₂ (AFRY, n.d.). Not to mention, the project includes features ensuring a climate-friendly streetscape, for example, the district's park includes a sunken playground acting as a water retention basin preventing floods during cloudbursts (AFRY, n.d.). Bäckaslöv presents an example of how the collaboration between various stakeholders allows to create a pleasant environment, adapt the area to possible future rising temperatures and waterways due to climate change, as well as conserve key ecosystem services.

The Västra Mark neighborhood, close to the center of the city, is an industrial site that is being renovated and converted into a mixed-used area accommodating residential buildings, shopping malls, sports arenas, and office hubs. As the previously industrial area did not seem to attract pedestrians or cyclists due to the lack of public realm and green spaces, the city of Växjö collaborated with colleagues in the Canadian city of Burlington to develop a green infrastructure scheme for the neighborhood based on an ecosystem services approach (Birnbaum, 2020). The plan included enhancing and preserving the existing green areas and developing new ones along with bike lanes, walkways, and improved public spaces. While it is a long-term project, the vision emphasizes the importance of developing a resilient and balanced district including ecosystem services. This project also aligns with the city's master plan. According to the Växjö staff working on this project, developing a vision for this neighborhood as well as collaborating with experts from Burlington has allowed them to increase their knowledge about ecosystem services. Birnbaum (2020) in her communication on Burlington and Växjö's ecosystem approach to planning and design presented the benefits of green spaces asserting that they do not only provide shade and reduce the dangerous impacts of hot weather but also offer cleaner air and filter rainwater into the soil. This reduces the pressure on the urban waste-water system. Also, it improves the overall health of people as cleaner reduces the risks of respiratory illnesses and health risks during heatwaves which alleviates health care costs; "Our physical and spiritual wellbeing is enhanced when we spend time in healthy natural spaces" (Birnbaum, 2020).

Växjö received various awards rewarding its commitment to ensuring environmental and sustainable development as since the 1960s the city had a strong emphasis on the environment (Tenje, 2018). In 2007, the city won the 'Sustainable Energy Europe Award'. It also received the European Green Leaf Award in 2018.

The European Commission (2018b) in its communication introducing Växjö as a winner of the European Green Leaf award, shed the light on various projects implemented by the city asserting that through the various environmental and climate initiatives, the city provided its citizens with a pleasant and livable urban environment.

4.4.5 Monitoring and Evaluation: A focus on sustainable development and mitigation rather than adaptation

As presented by the EEA (2020) on its Climate-Adapt online platform established to assure the sharing of adaptation information across Europe, national and regional Swedish governments are required to report their adaptation efforts on a yearly basis according to regulations. Additionally,

the adaptation strategy (NAS) is to follow a 5-year evaluation cycle. This includes vulnerability analysis, the monitoring, and assessment of implemented measures, as well as proposals and new measures. An expert council on adaptation was established by the government at the Swedish Meteorological and Hydrological Institute (SMHI) and has the responsibility to evaluate adaptation progress. Moreover, regional governments are responsible to monitor the work of local governments and municipalities (EEA, 2020).

In Växjö, initially, all administrations had the responsibility to hand in annual and interim reports to the municipality. However, as these reports were not as exhaustive as desired, each administration now has the responsibility to report directly to the municipality's environmental coordinator on a yearly basis (Johansson, 2016; Helsing, 2017).

In the city, natural resources are managed with the same diligence as financial resources, employing an ecological accounting system that trails environmental factors. This system is the "ecoBudget" tool which manages three areas: transport and energy, consumption, and waste, as well as water and nature conservation (Edwards, 2010). The ecoBudget determines an environmental budget, then implements measures and initiatives to reach the set targets, and lastly, it monitors the results through assessing the annual environmental account. This tool is used to ensure that the city's measurable goals defined in the environmental program are achieved, monitored, and evaluated. It defines key indices that are assessed twice a year. The assessment is illustrated with 3 different faces (a sad, an indifferent, or a smiling face) which allow determining gaps and areas requiring improvement (Edwards, 2010).

EcoBudget

EcoBudget is developed by ICLEI in collaboration with local authorities and is based on the concept that natural resources need to be managed with the high level of preciseness and care, similarly to the way financial resources are managed (EcoBudget Website, n.d.). It was developed in Germany in 1996. The initiative was then adopted in various cities across Europe including Växjö.

The Ecobudget, as a tool combining economic and ecological budgets, presents an interesting approach to monitor and evaluate the city's environmental and ecological transition, however, it is not very much inclusive of indices allowing to monitor and assess adaptation actions.

A member of the Växjö climate commission (interview, 2020) asserted that the city has various indicators for mitigation, waste management, and energy use, however, he underlined that it is more complex to monitor adaptation. He explained that the municipality is currently working on developing indicators to monitor its progress on sustainability, but these indicators are not directly focused on adaptation. To monitor mitigation and sustainability the city has both qualitative and quantitative indicators. However, to monitor adaptation efforts, the city keeps track of what kind of measures are implemented to increase the city's resilience to climate change and what is the status of these actions (whether the implementation is achieved and completed or not) (Member of the Växjö climate commission, interview, 2020). The city hasn't really elaborated quantitative indicators, but it is trying to assess actions by for instance understanding how many people are

living in proximity of a green area or trees asserted a Member of the Växjö climate commission (interview, 2020). He affirmed that “this gives an indication of the ability of people to access shaded area and the possibility to reduce the urban heating effect”.

Växjö develops a report on a yearly basis or two-yearly basis for the covenant of mayors and the impact of mayors to track the progress on both mitigation and adaptation efforts (Sustainability administrator at Växjö municipality, interview, 2020). Annual reports have been produced since 2007 to present the alignment of environmental actions with the city’s long-term objectives (Van Meeningen, 2016). These reports allow for transparency in the implementation of measures. They also ensure an evaluation of implemented actions and permit to determine whether adaptation actions or changes of the approach are necessary.

To ensure monitoring, evaluation, and reporting, the local government collects and compiles data from various sources, including national and regional governments, statistic agency and key local actors such as the local energy company, affirmed a sustainability administrator at Växjö municipality (interview, 2020). He added that the data is reported to the platforms, and only part of it is made publicly available. An environmental strategist at Växjö municipality (interview, 2020) asserted that insurance companies play an important role in the monitoring of adaptation, clarifying that “the cost of damages due to weather-related events is increasing, it means that the city is not doing enough to adapt”. This underlines the importance of considering various data sources including governmental and non-governmental agencies.

4.4.6 Understanding Success and Limiting Factors: Decentralization and the willpower of the municipality challenged by factors that are out of control

The Kronoberg county adaptation plan (Van Meeningen, 2016) asserted that one of the challenges is the need for improved cooperation across municipal boundaries, especially for municipalities with scarce resources. Moreover, some municipalities have mentioned that there is a need to learn more about how other organizations and municipalities are addressing the issue and adapting to climate change. “It is time-consuming, especially for smaller municipalities, to keep a close watch on the world in the area of climate adaptation” (Van Meeningen, 2016). Furthermore, many municipalities do not have an adaptation strategy and have poor knowledge about the vulnerability of the systems from a climate change perspective (Van Meeningen, 2016). However, it is important to underline that these challenges are general to all the municipalities of the region Kronoberg and are not particular to the municipality of Växjö.

In their book, “Local governments and climate change” Van Staden & Musco highlighted 3 key aspects that allowed the city of Växjö to succeed in implementing sustainable development plans. Firstly, the political unity and commitment of the city have been crucial, as, all parties, regardless of who wins the elections, consider environmental and climate issues particularly important (Van Staden & Musco, 2010). Secondly, the city of Växjö ensured the cooperation of local stakeholders and their involvement in the decision-making process. The cooperation was not only internal but also included the sharing of experiences and ideas with other cities within Sweden and the EU (Van Staden & Musco, 2010). Thirdly, the financial aspect has been crucial as the city of Växjö received

various funds from the national government and the EU allowing for the implementation of measures (Van Staden & Musco, 2010).

According to Cappelletti et al. (2015), various levels enabled Växjö to be a pioneer and exemplar in terms of ecological transition. First, the decentralization of the governance system in Sweden allocated a wide range of responsibilities to local authorities including energy management and environmental protection. Municipalities also have the capacity to establish financial incentives or disincentives and set standards. The taxes collected by the city of Växjö accounts for almost 67% of the total municipal budget and are used to finance their projects which ensured a dynamic local economy (Cappelletti et al., 2015). Second, intensive dialogue between different actors from various sectors allowed to define action plans and measures to be implemented as well as the responsibility of each actor. Not to mention, the dialogue extends beyond the city's boundaries to a wider exchange of knowledge through national and international networks (Cappelletti et al., 2015). Third, the strategic direction of the city of Växjö is unanimous as all political parties are committed to ensuring sustainable development and environmental protection. Therefore, the change of political majority in municipal elections does not disrupt or impact the city's long-term vision (Cappelletti et al., 2015). Fourth, the city established a great level of credibility due to its strong political commitment and the ability to present quantifiable and concrete results. This facilitated the obtention of funds from the national and the EU governments for various projects (Cappelletti et al., 2015). Fifth, the municipality is ensuring transparency through monitoring and evaluation. In addition, an "ecological budget" is set with the goal to manage natural resources similarly to financial resources. This tool is used by all companies and municipality services (Cappelletti et al., 2015). Sixth, the city is keen on developing a circular economy and optimizing flows. It is also working on establishing and strengthening links and relationships between various sectors and creating synergies (Cappelletti et al., 2015).

A sustainability administrator at Växjö municipality (interview, 2020) affirmed that the city not only aims at reducing the negative impacts of climate change and embracing positive effects but also believes that taking proactive measures reduces the costs of climate change. The municipality thus aims at identifying areas that require further actions and integrating adaptation in planning and daily processes to tackle climate change (Sustainability administrator at Växjö municipality, interview, 2020). Technicians, planners as well as other people working at the municipality level find it challenging to strengthen the capacity of existing and built infrastructure to climate impacts asserted EEA's (2016b) in its publication on stormwater management in Växjö. As a case in point, the streets and buildings limit the ability to broaden the Linnaeus Canal. The municipality is therefore looking at the possibility of implementing new measures in other sites within the city (EEA, 2016b). However, a member of the Växjö climate commission (interview, 2020) highlighted that even if the municipality oversees city planning, it does not own many of the lands or buildings, which makes it hard to intervene. Therefore, the cooperation of the municipality with property owners, citizens, businesses, and industries is crucial.

Implemented projects showed that one of the barriers and challenges is influencing residents to alter their behavior, especially when that entails changes in their lifestyle or financial sacrifices (Cappelletti et al., 2015). In a personal interview, a member of the Växjö climate commission (2020) affirmed that "we cannot force people to change their habits and the way they build their

houses, but we can influence them by developing some incentives”. An environmental strategist at Växjö municipality (interview, 2020) confirmed that statement, adding that “we can only nudge the public, but we can’t make decisions on their behalf”.

So far, more focus has been given to sustainable development and climate mitigation rather than adaptation asserted the sustainability administrator at Växjö municipality (interview, 2020), adding “more needs to be done in regard to protecting the environment and adapting to climate change because the city can’t keep on living on old merits”. He however clarified that the municipality has been progressively including adaptation into its practices as impacts are being felt.

An environmental strategist at Växjö municipality (interview, 2020) confirmed that new studies are currently being developed to close knowledge gaps and improve the understanding of the impacts of climate change on this region. He asserted that the new insights will be used as a basis for the development of a new adaptation plan. The department of security at the municipality also produces yearly risk reports which include natural and environmental risks. These reports are crucial to understanding issues that may arise and develop appropriate solutions to address them (Environmental strategist at Växjö municipality, interview, 2020).

4.4.7 Improving the Governance System in Place: Aiming to update adaptation strategy at a cyclical basis

As diffused by the EEA (2020) on its Climate-Adapt online platform founded to shed the light on adaptation efforts in European countries, in Sweden, an updated national adaptation strategy is to be published in 2023 based on new insights and knowledge.

In 2016, the Kronoberg regional adaptation action plan was suggested, and 10 regional actors submitted their comments to the county administrative board. This referral led to the development updated and additional measures. The regional adaptation plan is to be updated on a 5-yearly basis, with improved and more specific sub-goals deduced from the monitoring and evaluation of the effects of climate adaptation work (Van Meeningen, 2016).

Over the years, the municipality of Växjö shifted from energy transitions to a more integrated ecological transition including dimensions of sustainable developments. This transition started around the mid-1990s and changed the identity of the city (Cappelletti et al., 2015).

In its adaptation plan, the Växjö commune (2013a) presented various measures to fill knowledge gaps and improve its adaptive capacity. As a case in point, the commune is keen on refining monitoring and inspecting the types of trees and species to be implemented in urban environments considering human health and the natural environment. It is also keen on developing an improved understanding of future expected effects (Växjö commune, 2013a).

Växjö is aiming at updating its adaptation strategy on a cyclical basis to ensure it is integrating new insights (Environmental strategist at Växjö municipality, interview, 2020). A new adaptation plan was established in 2021, based on knowledge acquired since the development and implementation of the 2013 adaptation plan affirmed a Member of the Växjö climate commission (interview, 2021). He elucidated that the plan was prepared in coordination with at least one representative from each municipal department.

For the development of its updated adaptation plan, the city relied on a national support website⁶¹ which sets out guidelines for developing adaptation plans (Sustainability administrator at Växjö municipality, interview, 2020). The municipality also worked closely with the ‘Stockholm Resilience Center’ which considers that various aspects of resilience need to be considered while designing a resilient city including ensuring the flexibility of solutions in the face of change and disturbance (Sustainability administrator at Växjö municipality, interview, 2021).

The Växjö commune (2019) declared in its ‘climate sustainability agenda 2030’ its commitment to take local and global responsibility for the environment, people and the economy and invited different actors to contribute to this vision. It also affirmed that 2030 is not far away and stressed the need to act fast to meet the agenda 2030 goals.

The agenda 2030 (Växjö commune, 2019) presented the commune’s intention to work with different dimensions of sustainability through identifying various challenges to be addressed at a local scale. These challenges involve development in various fields including, biodiversity and ecosystem, transport and travel, urban planning, consumption and production, knowledge and education, labor market and business sector, health and well-being, equality, and gender quality, as well as safety and community (Växjö commune, 2019).

A sustainability administrator at Växjö municipality (interview, 2020) asserted that the city’s 2030 sustainability agenda is meant to be a guideline in preparation of the municipality’s yearly budget and is part of a broader vision, the city’s “Vision 2050”. He affirmed that “the city’s 2050 vision is to achieve climate neutrality with a complete switch to renewable energy”. To attain its fossil-fuel-free city ambition, Växjö is focusing proprietarily on 3 axes: energy efficiency, renewable energy, and urban planning. The city aims on using biomass for district heating and power generation, expanding a sustainable transportation network with increased reliance on biofuel and electric vehicles as well as ensuring a well-conceived urban plan that limits the need for car usage. The municipality is also pushing for the construction of green buildings throughout the city (Braff, 2020). Although the sustainability agenda is rather focused on energy-neutrality and sustainable development, Växjö defines resilience and stresses the importance of increasing the climate resilience of the city as part of its sustainable development strategy.

“In the definition of “Sustainable Växjö 2030,” we see the importance of including a resilience perspective. Resilience is about a system or society’s long-term ability to handle change and continue developing. Our society today already faces the consequences of climate and societal change. Therefore, we need to ensure that our community is equipped to handle these changes for both people, society, nature, and the environment.” (Växjö commune, 2019).

To determine if the city is moving in the right direction, the sustainability agenda (Växjö commune, 2019) underlined the importance of monitoring progress to assure continuous improvement efforts and defined 3 dates for the development of an in-depth follow-up analysis: 2022, 2026, and 2030. The evaluation responsibility is attributed to the municipality’s sustainability committee.

⁶¹ www.adaptationplan.se.

The EEA (2020) affirmed on its Climate-Adapt online platform established to assure the sharing of adaptation information across Europe, that Sweden has a well-developed disaster risk reduction framework that includes efforts for risk preparedness. The Swedish Civil Contingencies Agency is responsible to ensure coordination across various actors, levels, and sectors including climate adaptation, land use planning, and management of risks and natural disasters.

In Växjö, the “Värends Rescue Service” has been responsible since 2002 for providing its assistance for the residents of the municipality in cases of emergency. Its mission is to provide the protection of citizens against incidents impacting their properties, their health, and the environment. It cooperates with municipality members for crisis, fire, and risk management issues. It also has the responsibility to warn the public as well as to ensure the advice, education, and information for individuals (Värends Räddningstjänst, 2018).

The rescue service asserted in a communication on its online platform (Värends Räddningstjänst, 2018) that several crises or unfortunate events are likely to occur in the Kronoberg county (including storms, floods, fires, power outages, and epidemics) and affirmed that various measures have been developed in response.

The municipality of Växjö also has a crisis support group that is activated in the case of events affecting many people. The task of this group which includes psychologists, psychiatric nurses, social workers, and priests, is to provide support to the affected people and increase the psychological and social resilience of city residents (Sustainability administrator at Växjö municipality, interview 2020).

4.4.8 Assessing the Urban Climate Adaptation Governance of Växjö

The data - collected based on the review of various documents and interviews with different key stakeholders in the city of Växjö (presented in sections 4.4.1 – 4.4.7) - allowed to answer the set of 50 close-ended questions that were presented in the methodology (section 3.6.1) introducing the urban climate adaptation governance index.

The application of the developed index to the city of Växjö has shown that the assessed city has a favorable climate adaptation governance approach with a value of 9.0/10 (*refer to appendix III – table 15*). This means that the local government is aware of the importance of increasing urban resilience in response to climate events through the development of corresponding adaptation strategies based on an in-depth understanding of local climate impacts and vulnerabilities. Nevertheless, even a city like Växjö, with a favorable adaptation governance approach could still be vulnerable to climate impacts given that climate adaptation is a process that needs continuous monitoring and improvement.

The figure below (*figure 44*) projecting a visualization of the urban resilience score shows that the city of Växjö is doing well in almost all the defined areas of governance. The results show that there is room for improvement in the area of ‘implicating and mobilizing actors’ and ‘monitoring and evaluation’. The city seems exemplar in the field of climate adaptation and urban resilience, given that addressing environmental matters and ensuring the sustainable development of the city has been for the past decades a top priority for key decision-makers at the heart of the municipality.

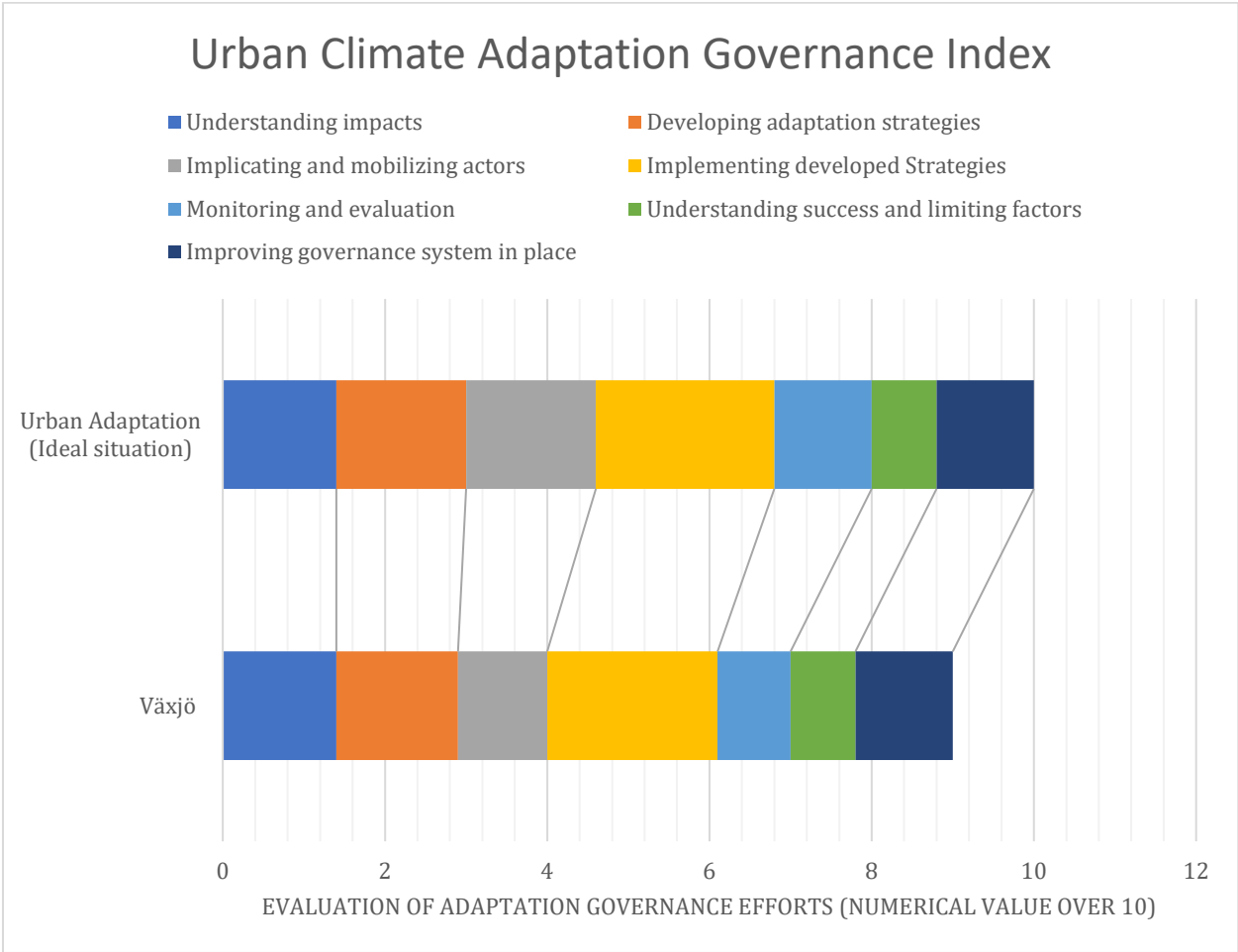


Figure 44 Visualization of the index score of the City of Växjö across various areas of climate adaptation governance.

The climate adaptation governance index (detailed in appendix III-table 15) shows that the city of Växjö could improve its adaptation governance by implicating and mobilizing actors through establishing collaborations with the university to produce knowledge relevant to climate resilience and adaptation. The city could also establish partnerships with the private sector to increase the resilience of the city to climate change as existing public-private partnerships are rather focused on GHG emissions and mitigation. The results show that Växjö could improve its adaptation governance by ensuring that the collaboration among various actors within the municipality persists even after the development of the adaptation plan.

The city could also invest in developing a thorough monitoring and evaluation system embracing qualitative and quantitative indicators and allowing to determine the progress of its adaptation actions to increase its adaptive capacity and improve urban resilience.

4.5 The case of San Sebastian, Spain



Figure 45 The city of San Sebastian. Source: Google Maps, 2021.

The case of San Sebastian is examined to develop a better understanding of climate governance in Spain, a country where regional governments have a great deal of competencies.

To assure data collection, published literature was reviewed including documents and articles developed by environmental agencies in the Basque Country and San Sebastian as well as national and international adaptation platforms. Climate and urban plans developed by the municipality of San Sebastian as well as publications on the city's official website were examined as well. The data collection was also supported by articles and documents published by the local and international press.

For this case, a field visit was conducted to develop a better understanding of the urban layout of the city and the presence of green and blue infrastructure systems. However, to adapt to coronavirus safety guidelines, online interviews were conducted with various actors including, an associate at the Public Society for Environmental Management of the Basque Government - Ihobe (2021), an environmentalist at the San Sebastian City Council (2021) as well two experts at a local consulting company working closely with the local municipality to promote climate policies and ensure sustainable development who will be referred to respectively as 'San Sebastian Climate consultant 1' (2021) and 'San Sebastian Climate consultant 2' (2021). An interview was also conducted with an expert at a private research and technology center supporting the efforts of the municipality of San Sebastian, who will be referred to as 'San Sebastian climate expert' (2021).

The data collected through these interviews served to complete and build on the information collected through the initial literature review and allowed to develop a better understanding of the current situation in San Sebastian as well as the city's effort to adapt to climate change.

The primary and secondary data collected is synthesized and organized following the 7 areas of focus in the governance of climate adaptation defined in the conceptual model (Section 3.4) as presented below.

San Sebastian, also known as Donostia, is a mid-sized European city situated in the Basque country. The latter constitutes an autonomous region in the north of Spain that has its own president. Important competencies are attributed to the Basque Country which has a great level of self-governance in various areas including: Territorial Planning and Housing, Environment, Public Governance, Health, Economy, Development and Infrastructure, Labor and Justice, Social policies, Education, Tourism, Culture, and Trade (Faíña, et al., 2006).



Figure 46 The 17 neighborhoods of San Sebastian. Source: *Donostia.eus*.

San Sebastian is a coastal city on the shore of the Atlantic Ocean overlooking the Biscay gulf. It has three beaches, Zurriola, Ondaretta, and Concha, and is surrounded by hilly areas, Mount Igeldo (Overlooking Concha Bay from the west), Mount Adarra (South of the city), Mount Ulia (spreading east to Pasaia), and Mount Urgul (adjacent to the old part of San Sebastian – Parte Zaharra). Over the last two centuries, the city was to a large extent built on the River Urumea’s wetland. The district of Riberas de Loiola, Amara Berri, and the city center lie on the former riverbed which was redirected to its current canalized course at the beginning of the 20th century (Sada & Sada, 2007).

The city’s urban plan follows a dense grid pattern. It is the consequence of rebuilding work carried out in the 1800s, following the devastating war against Napoleon which led to the destruction of the city (García-Hernández et al., 2017).

The municipality is home to more than 180,000 inhabitants (Instituto Nacional de Estadística, 2019) and attracts many tourists. The service sector (i.e., tourism, transportation, and commerce) dominates the city’s economy. San Sebastian’s touristic character goes back to the 19th century when members of the aristocracy spent their summers, mainly, due to its privileged location stretching on the Cantabrian Sea (García-Hernández et al., 2017). Today, the city continues to be an attractive touristic destination as it is visited by over 1.5 million tourists per year, with a higher inflow in summer months (García-Hernández et al., 2017).

The city stretching along the Atlantic Ocean presents a temperate oceanic climate, characterized by mild temperatures, high humidity, frequent cloudiness, and abundant rainfall distributed regularly throughout the year (Feliú, et al., 2017). However, San Sebastian is experiencing increased frequency in extreme climatic events including heatwaves, river flooding, and severe storms (Estreguil et al., 2019).

4.5.1 Understanding Impacts and Vulnerabilities: Collaboration with research and technology centers to map vulnerability at a local scale

In 2007, The K-egokitzen project “Impact of climate change and adaptation in the Basque country” was implemented with the main objective to develop an effective regional adaptation program. The latter aims at proposing measures to increase the resilience of urban areas, infrastructure, water resources as well as marine, agricultural and natural ecosystems. The project was coordinated by an environmental unit composed of 12 research groups from the University of the Basque country and two others from Tecnalia Corporation centers (Otto-Zimmermann, 2011).

In 2010, knowledge maps of impacts of climate change on the Basque country were drawn. The developed maps exposed the likelihood of floods from the elevation of sea levels along the whole Basque coastline considering various climate scenarios asserted an associate at the Public Society for Environmental Management of the Basque Government - Ihobe (2021) in an interview.

The Basque government (2015) affirmed in its ‘Climate Change Strategy of the Basque Country to 2050’ known as ‘Klima 2050’ that the coastal zone and urban environment, as well as the water sector, are considered areas of priority due to their strategic importance and vulnerability to climate change. It also stated that the most considerable impacts are the intensification of the UHI effect in summer periods and river and tidal flooding. It evoked that this could have serious consequences on the economic, social, and environmental sphere including damages to infrastructures systems and houses, drops in productivity, and loss of businesses as well as harm to human health and, in some cases, death.

The municipality of San Sebastian is working closely with research and technology centers as well as consultancy firms to develop an improved understanding of the impacts of climate change at a local scale, asserted an Environmentalist at the San Sebastian City Council (interview, February 2021). He added that the city has also collaborated with the University of Navarra on a European project of resilience to climate change.

A thorough diagnosis (Feliú, et al., 2017) was carried out for the preparation of the local adaptation plan (García et al., 2017) in San Sebastian. The city’s adaptation plan (García et al., 2017) asserted that the diagnosis was crucial to define the areas of priority to establish an efficient and effective political response.

To develop the diagnosis of the impacts of climate change on San Sebastian, an analysis of historical trends was carried out based on the study of the changes in temperatures, precipitation patterns, and humidity of the time series between 1929 and 2015 from records belonging to the Igeldo weather station. The results presented in the diagnosis showed that during the past years, the average temperature has increased by 0.8 °C as both the maximum and the minimum temperatures have witnessed positive trends (Feliú, et al., 2017). Evidence portrayed that the days of cold are decreasing in number and the days of frost are disappearing. 2100 projections foresee

a continuous increase in average temperature. The maximum temperature is expected to increase by 2.8 °C considering a worst-case scenario. The number of nights with temperatures exceeding 20 °C is expected to increase between 5 and 15 by the end of the century which could have impacts on people's health (Feliú, et al., 2017). Also, projections estimate that heatwaves are likely to occur between 2 and 4 times per year by the end of the century. A great uncertainty lies in respect to future precipitation projections. However, the number of days with heavy rainfall is likely to augment and the number of consecutive days without rain is likely to increase between 14% and 45% (Feliú, et al., 2017).

The diagnosis (Feliú, et al., 2017), serving as a basis for the development of a municipal adaptation plan, introduced diagrams graphically representing cause-effect relationships of climate variables and extremes events on various sectors including energy, tourism, water supply, and demand, built environment, infrastructures, and public health. The impacts that were considered are the swell and the sea level rise, river floods, rain floods, heatwaves and their impacts on health as well as the increase of temperatures and its impacts on biodiversity (Feliú, et al., 2017). To contextualize the vulnerability and risk analysis, data was provided by the City of San Sebastian Itself through its various departments and services (i.e., tourism, urban planning, environment, sanitation, etc.). The data was complemented by information from various institutions and non-local organizations such as the Basque Government, Aranzadi Science Society⁶², the Basque water agency among others (Feliú, et al., 2017).

In the city, addressing floods and heat stress are among the action areas of high priority affirmed San Sebastian Climate consultant 1 (interview, 2021).

An associate at the Ihobe⁶³ (2021) explained that his organization works in collaboration with public administrations, businesses, and citizens to raise awareness and promote the Basque country internationally as a region that is actively addressing environmental issues and ensuring sustainable development. "Seventy-two percent of the population considers that protecting the environment and combating pollution are urgent and immediate issues" claimed the Basque Government (2015) in its climate strategy 'Klima 2050'.

The municipality of San Sebastian (2019) declared in a press release that, according to a study determining how local citizens perceive climate change (conducted by the Cristina Enea Foundation and presented by the Councilor for Ecology of the San Sebastian City Council Enrique Ramos), 94% of the people of San Sebastian consider that this global issue is "unquestionable", compared to 2% who deny its existence and 4% who say they don't know much about it. In this communication, the Councilor for Ecology of the San Sebastian City Council asserted that the level of concern of the people of the city has increased in recent years as, in 2012, only 80% showed their alert to climate change while 18% denied the existence of the problem (Municipality of San Sebastian, 2019). Most citizens believed that the problem is not being given the importance it deserves, while 17% considered that it is being given the importance it deserves or more, elucidated the press release developed by the municipality of San Sebastian (2019). This analysis

⁶² an NGO situated San Sebastian with the aim of conducting and diffusing research in the fields of the natural and human sciences.

⁶³ Public Society for Environmental Management of the Basque Government.

is grounded on data presented in annual sustainability reports, data from a 2017 sociological survey conducted by the Basque government, and the Barometer of the center of sociological research corresponding to November 2018.

According to a San Sebastian climate expert (interview, 2021), the city's residents have a good level of awareness of climate change in comparison to other cities in Spain. This was confirmed by an associate at the Public Society for Environmental Management of the Basque Government (interview, 2021) who asserted that "in general, Basque residents have a high level of awareness to climate change, especially in cities like San Sebastian and Bilbao, as over the past 3 decades, sea level rose by approximately 70 mm and had some impacts on the region".

The municipality is working on communications and awareness campaigns to inform the public about the impacts of this global phenomenon on their city and their daily lives, "but it is still a work in progress, and more effort is still needed," affirmed a San Sebastian Climate consultant 1 (interview, 2021). He elucidated that in recent years, the city has faced various extreme weather events, generating a lot of damage, "but on the "upside", these events allowed the local citizens to visualize and develop an improved understanding of the impacts of climate change and its ramifications on the city" (San Sebastian Climate consultant 1, interview, 2021).

The rise of the Average Sea Levels and the intensification of extreme events:



Figure 47 urban areas with high relative risk (percentile > 80) due to the impact of waves and rising sea levels. Source: Feliú, et al., 2017.

The diagnosis (Feliú, et al., 2017) serving as a basis for the development of a municipal adaptation plan underlined that, in the Biscay gulf, between 1980 and 2010, the annual sea surface temperature has increased by 0.15 °C per decade. Between 2011 and 2015, water temperatures have surpassed the average of the previous decades and increased by 0.19 °C per decade (Feliú, et al., 2017). Moreover, between 1944 and 2015, the sea level has risen by 2-3 mm on average per year. The analysis predicts that the sea level is expected to rise 64 cm by 2100, considering a high GHG emissions pathway, which puts the area at the risk of flooding in periods of high tides. The

situation poses the risk of submerging urbanized coastal areas, the erosion on sandy beaches and bars, and the intrusion of saltwater into estuaries and groundwater, and the loss of wetlands (Feliú, et al., 2017). Simulations are conducted showing the impacts of the sea level rise on the city of San Sebastian. The climate change adaptation plan allowed for the development of an index permitting the identification of neighborhoods that are most vulnerable to the rise of sea level. These areas are highlighted in the figure above (*figure 47*) and include, Barrio Antiguo (the old neighborhood), the Center (Old Town and Miraconcha Promenade), Loiola, and Gros (Feliú, et al., 2017).

In 2019, a study of Estimation of the impacts of climate change on the Basque littoral, was developed as a result of a collaboration between Ihobe (a public company attached to the Department of Economic Development, Sustainability, and the Environment of the Basque Government) & Azti Tecnalia (Scientific and Technological Center). The study presents projections of the impacts of sea-level rise on urban environments including the city of San Sebastian and its scope included the beaches of La Concha, Ondarreta, and Zurriola as well as the beach of Santa Clara Island. The main interest of the analysis is to quantify the contribution of sea-level rise to the retreat of the coastline. The results show a comparable anticipated shrinking of the coastline for the Ondarreta and La Concha beaches, with average values of 4, 7, and 14 m for the years 2030, 2050, and 2100 respectively, and lower recoil values for the Island of Santa Clara, of 1, 2 and 5 m for the years 2030, 2050 and 2100 respectively (Ihobe & Azti Tecnalia, 2019).

This study was used as a basis for beach-management recommendations to alleviate the main identified effects of climate change.

In February 2014, a heavy storm hit the city of San Sebastian, with strong waves exceeding 10 meters in height, underlining the urgency to act, and pushing the city in the direction of developing adaptation measures asserted an Environmentalist at the San Sebastian City Council (interview, February 2021). A press article (Davies, 2014) communicated that the high and strong waves led to the destruction of walkways and coastal roads in San Sebastian. Also, tidal flood water reached the old town of the city and caused damages to various buildings and commercial shops (Davies, 2014).

In addition to the risk of flood due to sea level rise, the city of San Sebastian is also at risk of river floods. Therefore, a flood mapping was done considering the areas affected by the Urumea River. The mapping does not however include other watercourses or channels that could pose flood risks (Feliú, et al., 2017). The areas that are at risk of flood due to heavy rainfalls have also been identified and mapped (Feliú, et al., 2017). The 'Centro' neighborhood, particularly the 'Área Romántica' is exposed to both, floods due to the rise of sea level as well as the risk of river flooding due to its proximity to river 'Urumea' (Gutiérrez, et al., 2017).

The city of San Sebastian is already dealing with the flooding of the banks of the Urumea river and the urbanized coastal areas. As a case in point, heavy rainfalls in 2004 and 2006 led to major floods submerging the riverbanks, causing damages to homes and local businesses in the affected area, as well as traffic troubles particularly in the city districts of Martutene and Hernani. Moreover, several homes suffered from electricity cut-offs due to storm damages of the Iberdrola plant (thinkSPAIN team, 2004).

Heatwaves and Urban heat island effect:

In Spain, more than 80 heat waves have been registered since 1975 (Gómez, 2019). According to the Igeldo Station in San Sebastian and as presented by the diagnosis (Feliú, et al., 2017) used as a basis for the development of a local adaptation plan, there is twice as many heatwaves in comparison to the reference period (1961-1990) with currently around 2 heatwaves per year. Projections foresee an increase in the number of extreme heat events from 2 to 4 heatwaves per year and an increase in the minimum value of maximum temperatures between 40% and 88% considering RCP 4.5⁶⁴ and RCP 8.5⁶⁵ scenarios respectively (Feliú, et al., 2017). The diagnostic report for climate adaptation in San Sebastian presented the ramifications of heatwaves on human health (Feliú, et al., 2017).

A thermal map of the city of Donostia/San Sebastian was elaborated (Gutiérrez, Mendizabal, & Feliú, 2019) using UrbClim, an urban climate model that calculates surface heat flows based on energy balance. In this model, the surface is divided into 3 types of ground covers: vegetation, bare soil, and urban surface. For each of the three types of ground cover, separate water and energy balances are considered (Gutiérrez, Mendizabal, & Feliú, 2019). The elaboration of this thermal map allows to determine various indices including the duration of heatwaves, their frequency, and intensity. These indices are crossed with socio-economic indicators to be able to identify priority areas for intervention and are related to different sectors and to the city's municipal departments (including emergency, planning, and health among others) to support decision making (Gutiérrez, Mendizabal, & Feliú, 2019).

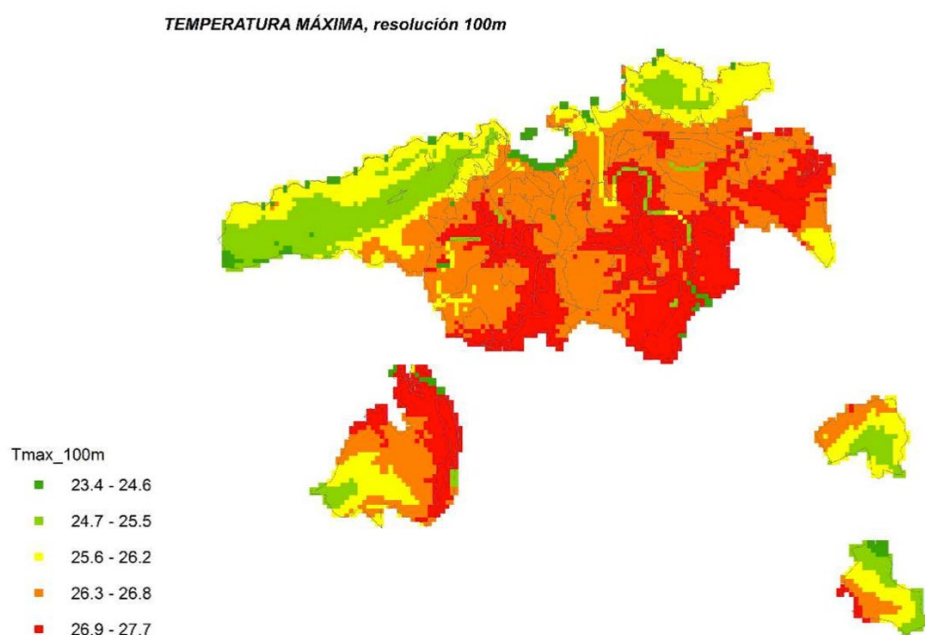


Figure 48 Thermal map presenting the mean values of maximum temperatures in the summer period (may - September) of the year 2003. Source: Gutiérrez, Mendizabal, & Feliú, 2019.

⁶⁴ RCP 4.5 is considered by the IPCC as an intermediate scenario where emissions peak around the year 2040, then decline.

⁶⁵ The RCP 8.5 is considered as a worst-case scenario where emissions continue to rise throughout the 21st century

According to the developed thermal map presenting mean values of maximum temperatures in the summer period (May – September) of the year 2003 (*Figure 48*). The lowest values of maximum temperature correspond to the coastal strip and high areas of the city such as Ategorrieta and Igeldo. The maximum temperature increases in the inland areas with low elevations as the “refreshing” influence of the sea is lost. It is worth mentioning that the temperature is slightly lower on the riverbeds of the Urumea River which acts as a temperature regulator throughout its course.

The Centro neighborhood and specifically the Romantic Area is vulnerable and exposed to the increase in temperature and the heat island effect due to the high percentage of sealed and mineralized surfaces and scarce vegetation cover (Gutiérrez et al., 2017).

The city of San Sebastian is already facing the consequences of the rise of temperatures and the intensification of the UHI effect. As a case in point, in the last week of July 2019, the temperatures broke new records for maximum temperature in San Sebastian in its 92-year history as underlined in a press article (Torres Benayas, 2019). The article communicated that the university hospital in the city had no air conditioning and patients were in distress (Torres Benayas, 2019).

Droughts and lack of water availability:

The analysis of the evolution of rainfall for the year 2019 in Spain shows that various regions are dealing with meteorological droughts including Asturias, Madrid, Mallorca, La Palma, Tenerife, and the Basque Country. The Basque government (2015) affirmed in its ‘Klima 2050’ climate strategy that it considers tackling water supply as an area of priority in the field of climate adaptation as changes in temperature and precipitation is likely to impact the availability of water resources. Climate predictions reflect a decrease in average flows as well as the likelihood of a greater frequency of droughts and seasonal variability. In response, the Basque government (2015) asserted in its strategy that it opts for developing new drought indicators and thresholds considering new ecological flows as well as future flow projections and demand for water.

San Sebastian’s diagnostic report (Feliú, et al., 2017) highlighted that there is no clear trend concerning the number of consecutive days without rain. Despite the uncertainty, projections foresee an increase between 14% and 45% considering RCP 4.5 and RCP 8.5 scenarios, respectively (Feliú, et al., 2017). Nonetheless, a San Sebastian Climate consultant 1 (interview, 2021) affirmed that the lack of water availability is not really an issue for the city of San Sebastian and therefore it is not really elaborated in the diagnostic used as a basis for the development of the local adaptation plan. He added, “the reason for that is, San Sebastian is one of the rainiest cities in Spain and receives on average of 1500 mm of rain per year”. This was also confirmed by an Environmentalist at the San Sebastian City Council (interview, February 2021) who asserted that “the city is likely to deal with heatwaves and periods in which the degree of humidity of the vegetation drops increasing the risks of fires, but that is the extent of it”.

The city could face the issue of drought in the coming decades, however, now it is not critical and thus not considered an area of priority (San Sebastian Climate consultant 1, interview, 2021; Environmentalist at the San Sebastian City Council, interview, February 2021).

4.5.2 Developing Adaptation Strategies: A declaration of climate emergency and efforts to adapt to rising sea levels

The Spanish system of governance encompasses the levels of competencies in charge of addressing environmental matters: the national, the regional, and the local level (del Pozo, 2019). The national government, particularly the ministry for ecological transition, is responsible for the main coordination of environmental actions as well as for the development of supervision mechanisms. Regional governments endorse environmental plans and develop legislations related to their territorial scope and act as a link between the national government and local municipalities (Associate at the Public Society for Environmental Management of the Basque Government, interview, 2021). They are usually responsible to carry out environmental procedures and grant corresponding permits (del Pozo, 2019). Municipalities are mainly responsible to address issues at a local level (e.g., waste management, mobility, etc.). Environmental agencies and bodies, such as the Spanish office for climate change (OECC) and the forces responsible for the protection of the environment (SEPRONA), enforce and support the three levels of governance (del Pozo, 2019).

In Spain, the first national plan to adapt to climate change (2006-2020) was adopted by the Council of Ministers in 2006 after a process of consultation between the central government and the 17 communities (including the Basque country) which have a broad autonomy (Caude et al., 2015). The NAP covered fifteen themes: water, forests, agriculture, biodiversity, inland fishing and hunting, marine ecosystems, coastal areas, mountains, soil, transport, industry and energy, health, tourism, finance and insurance, construction, and town planning. A second national adaptation plan (2021-2030) was developed serving as a planning instrument promoting coordinated action across the country in the next decade. Its main objective is to avoid or reduce present and future damages derived from climate change and to build a more resilient economy and society. It incorporated the new international commitments and considered the most recent knowledge on climate risk, taking advantage of the experience acquired from the development of the first national adaptation plan.

In support of the first national adaptation plan, the country published 3 work programs respectively in 2006, 2009, and 2014 (Lukat et al., 2016). The first program, approved in 2006, targeted the realization of regional climate scenarios and knowledge actions on the various themes (Caude, et al., 2015). The second work program, adopted in July 2009, for the period 2009-2012, continued the work of scenarios and assessment of sectoral impacts initiated in the previous program, provided the identification of the legal tools necessary for the integration of adaptation in sectoral policies, and aimed at mobilizing the various stakeholders as well as developing a monitoring system and respective indicators. The second work program was based on strengthened research and reinforced coordination between the national and regional levels. A third work program, incorporating the same thematic priorities, was adopted for the period 2014-2020 to mobilize the European Union's financial instruments (Caude, et al., 2015).

Almost all Spanish regions have adopted adaptation strategies or regional action plans (Lukat et al., 2016). In 2002, the Basque region developed an environmental strategy for sustainable development (2002-2020) to reduce the pressure and alleviate climate change. It also actively participated in the setting up of the 'Network of Regional Governments for Sustainable

Development (nrg4sd) (Associate at the Public Society for Environmental Management of the Basque Government, interview, 2021).

In 2008, the first Basque plan to combat climate change was developed (2008-2012). In 2011, a regional Energy Strategy (3E 2020) was established. The following year, an urban planning manual for adaptation and mitigation of climate change was developed as well as a guide to preparing municipal climate adaptation programs. In 2014, the Basque country engaged itself in the “Compact of regions”. A year later, the Basque government adopted a new climate change strategy “Estrategia de Cambio Climático 2050 del País Vasco” (Klima 2050) aiming to reduce carbon dependency and minimize the region’s vulnerability to climate change by 2050.

As 2050 appears to be distant in time, the Basque government defined 70 lines of action in its climate strategy (Klima 2050), including adaptation plans, for the first period (horizon 2020) as an initial step towards achieving the climate objectives set for the year 2050.

To adapt to climate change, the region aims at developing methodologies and support tools for municipalities including vulnerability maps, standards for urban resilient designs, guides, and best practices affirmed an associate at the Public Society for Environmental Management of the Basque Government (interview, 2021). He added that the regional government is invested in promoting nature-based solutions and green infrastructure to ensure sustainable territorial development and adapt to climate change. The Basque government (2015) affirmed in its climate strategy that it aims at integrating climate adaptation to territorial and urban planning instruments. It also asserted that it has the objective to work on municipal adaptation measures and policies in the framework of the Udalsarea⁶⁶ initiative as well as mobilizing and implicating the actors to take climate action. To assure the development and implementation of appropriate adaptation measures, the regional government provides territorial actors with technical and economic resources (Associate at the Public Society for Environmental Management of the Basque Government, interview, 2021).

According to an associate at Ihobe (interview, 2021), municipalities need to collaborate with the regional government as sometimes it makes more sense to do some studies or projects on a larger scale. He added, “the city can always benefit from information developed by the regional government in order not to do the task twice”.

The collaboration between the municipality of San Sebastian and the Basque country is assured within the framework of the Udalsarea network of Basque municipalities towards sustainability affirmed an environmentalist at the San Sebastian City Council (interview, June 2021). The city works closely with the regional government and frequent contact is ensured. The technical commission and the political committee of the city of San Sebastian meet yearly with the regional government. Also, San Sebastian benefits from climate funding from the provincial and regional council (Environmentalist at the San Sebastian City Council, interview, June 2021).

In Spain, the 7/1985 law of April 2, gave the municipalities that have more than 50.000 inhabitants the responsibility and competencies in term of legislation in matters of environmental protection asserted an environmentalist at the San Sebastian City Council (interview, February 2021). He explained that the city has competencies to address issues such as mobility, air quality, waste management, biodiversity, and energy efficiency. Additionally, the city council of San Sebastian

⁶⁶ Udalsarea is a Basque network bringing together 200 municipalities to ensure a sustainable development.

carries the responsibility to develop an urban plan, which is a crucial starting point for adapting the territory to climate change (San Sebastian Climate consultant 1, interview, 2021).

The city has the legal obligation to develop sustainable actions, establish an energy sustainability commission and collect a series of data related to sustainable energy planning. However, the city goes beyond its legal obligation as San Sebastian is particularly vulnerable to the rise of sea level affirmed an Environmentalist at the San Sebastian City Council (interview, February 2021). He elucidated that “the legislation helps but it is mostly the willingness to act that is pushing the local government to take appropriate climate action”

The municipality of Donostia/San Sebastian developed an agenda 21 in 1998, this agenda focused mostly on sustainable development incorporating mitigation actions (Environmentalist at the San Sebastian City Council, interview, February 2021). In 2008, the city approved its first Plan to Combat Climate Change (2008-2013), which already addressed the need for work on both mitigation and adaptation (Feliú, et al., 2017). This initial plan introduced “timid” notions of adaptation and focused more on limiting emissions (San Sebastian Climate consultant 1, interview, 2021). In 2014, San Sebastian adhered to the covenant of mayor’s adaptation program which implicates the drafting of a climate change adaptation plan for the city. The following year, the city updated its local agenda 21 action plan in preparation of the ‘Hiriberdea 2030’ environmental strategy and adhered to the ‘Compact of Mayors’ (Feliú, et al., 2017). It also developed a smart city plan for the period 2016-2020. In 2017, San Sebastian collaborated with the Basque Government to develop a climate change adaptation plan “Plan de Adaptación al Cambio Climático de Donostia/San Sebastian” affirmed an associate at the Public Society for Environmental Management of the Basque Government (interview, 2021). The plan was developed by experts and was coordinated with employees working at the municipality in various areas including sustainable urbanism, urban maintenance and services, projects and works, strategic planning, territorial information and cartography, firefighting and rescue, water exploitation and sanitation, tourism, and social action (Feliú, et al., 2017). The adaptation document is not a plan to develop a public policy, but a plan that backbones all public policies of the municipality (Environmentalist at the San Sebastian City Council, interview, February 2021).

The developed adaptation plan (García et al., 2017) suggested the implantation of new infrastructure projects and technologies, the review of regulations, the investigation and compilation of information, and the sharing of knowledge. The adaptation plan presented 31 concrete actions (*refer to appendix II-table 11*). It defined for each action, the type of measure (grey, green, or soft adaptation measures), the addressed impact, the implementation term (short, medium, or long), the priority of action (high, medium, low), the estimated cost as well as responsible actors or departments. The plan included 8 general measures to increase the resilience of the city to all impacts of climate change. 12 actions are particularly developed to deal with the UHI effect and heatwaves, and 11 measures are developed addressing pluvial, coastal, and fluvial floods. However, a casual observation reveals that no adaptation action is developed to address the lack of water availability or drought. San Sebastian Climate consultant 1 (interview, 2021) clarified that at this current stage there, no measures are proposed as the city is not dealing with issues related to the lack of water availability.

31 Proposed Actions	Priority level	Number of actions	Addressed Impact	Number of Actions
	High Priority	17	Floods	7
			UHI Effect /Heatwaves	4
			All impacts	6
	Medium priority	14	Floods	4
			UHI Effect /Heatwaves	8
All impacts			2	

Table 3 Adaptation actions presented in the city’s action plan organized by priority level (High/Medium). Data retrieved from: García et al., 2017.

The table above (table 3) organizing the 31 proposed measures presented in the city’s action plan by priority levels shows that most actions that are considered of high priority address flood issues, while most actions that are considered of medium priority address UHI effect and heatwaves issues. This defines the city’s priorities in addressing climate impacts.

The diagram below (figure 49) organizing the measures proposed by the action plan by term shows that only 3 out of 31 measures (9%) reflect on long-term impacts while 88% of the adaptation measures are short, short/medium- or medium-term actions. This underscores the focus of the city on short and medium-term measures rather than long-term actions.

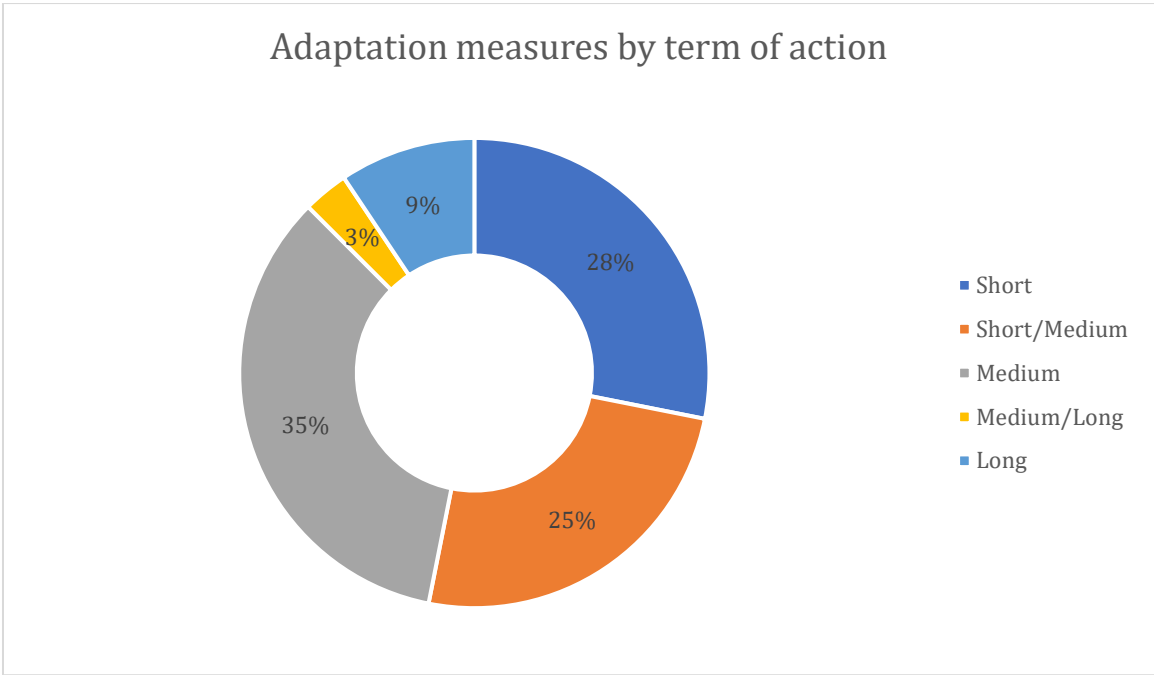


Figure 49 Adaptation actions presented in the city’s action plan organized by term of action (Short – Medium – Long). Data retrieved from García et al., 2017.

The city’s adaptation plan (García et al., 2017) suggested concrete measures such as the reinforcement of breakwaters grid to protect against waves, the channeling of the Urumea river, special urban projects in vulnerable areas for the protection against floods, as well as the exploration and the application of natural solutions and sustainable urban drainage systems. It also highlighted the importance of increasing the share of greenery and permeable surface in public spaces and buildings.

In 2018, San Sebastian adopted its climate action plan (a 2050 roadmap), the “Plan de Acción Klima 2050 de Donostia / San Sebastián” (GEA21, 2018). Various existing strategies or programs were already aligned with the aims of the roadmap. Nonetheless, according to a report developed by ‘energy cities’ introducing local energy and climate roadmaps of 5 European cities (Veith, 2018), several plans within the municipal administration operate outside the scope of the roadmap. This underlines the necessity to redefine the city’s governance structure and the administrative culture to align the plans of each administrative body to the roadmap and assure transversality. The report (Veith, 2018) asserted that each municipal department is responsible to incorporate energy and climate objectives into its proper plan for the city’s roadmap to succeed, elucidating that “such an integrated approach exemplifies how climate mainstreaming can be introduced into the everyday working culture of the city administration”.

The city asserted in its climate action plan (Klima 2050) that it aims at increasing the green surface by 15% by 2030 (GEA21, 2018). Therefore, it proposes adapting urban regulations and developing urban design criteria that incorporate green solutions. The city’s climate action plan affirmed that these initiatives have co-benefits, “...they help reduce the risk of flooding or heat waves, as well as reconnecting citizens with nature in a direct way and to improve many other aspects of health and quality of life” (GEA21, 2018).

According to the city’s action plan (GEA21, 2018), San Sebastian is seeking to develop town planning with climatic criteria to limit the artificialization of municipal land from exceeding 45%. The establishment of indicators for decision-making in matters of adaptation to climate change and consolidating a climate management structure within the municipality is seen as crucial (GEA21, 2018). The city’s adaptation plan (García et al., 2017) also highlighted the importance of developing and improving knowledge through mapping and modeling and underlined the importance of disseminating the produced knowledge within the municipal workforce and among citizens and private actors.

In November 2020, an update of the city’s adaptation plan was carried out, considering the necessity of the incorporation of advances in knowledge, the need for a higher level of concretion of measures, the necessity of attracting external funds as well as the need to communicate more on progress and achievements to the public and raise awareness (Gutiérrez et al., 2020).

The municipality of San Sebastian is mindful that developing new strategies, adapting existing legislation, and using more efficient technologies is not enough to mitigate and to adapt to climate change affirmed San Sebastian Climate consultant 1 (interview, 2021). The city asserted in its climate action plan (Klima 2050) that a behavioral and cultural change is also necessary coupled with the involvement of all stakeholders (GEA21, 2018). In March 2020, the local government board approved the declaration of climate emergency in the city. This declaration assumed the fulfillment of binding political commitments and the development of new goals that are more ambitious than the current ones. The declaration of emergency also implies redirecting the city’s resources to face the climate crisis and the problems that come along (Environmentalist at the San Sebastian City Council, interview, February 2021).

The city’s commitments to climate action, on a long-term horizon, are not affected by local elections as, generally, they are not opposed by any political party affirmed an Environmentalist at the San Sebastian City Council (interview, February 2021). He explained that the election of a

new council and mayor could, however, affect the budget dedicated to climate action and its “ranking” or position on the priority list.

The timeline of strategy development at a local, regional, and national scale serving climate adaptation efforts in San Sebastian (*figure 50*) shows a balance between top-down and bottom-up governance approaches. There seems to be no dominance of regional and national strategies and actions over environmental initiatives taken at a local scale. Concretely, San Sebastian has been interested in sustainable development as of 1998, 4 years prior to the development of a sustainable development plan at a regional scale.

In the governance of climate adaptation, the city has not been exceptionally proactive as it only developed its first adaptation plan in 2017, almost 9 years after the development of a national adaptation plan. It is however important to underline that San Sebastian developed a plan to combat climate change in 2008, the same year a first Basque plan to combat climate change was developed and two years following the adoption of a NAP, yet the city’s climate plan was more focused on mitigation and included “timid” notions of adaptation (San Sebastian Climate consultant 1, interview, 2021).

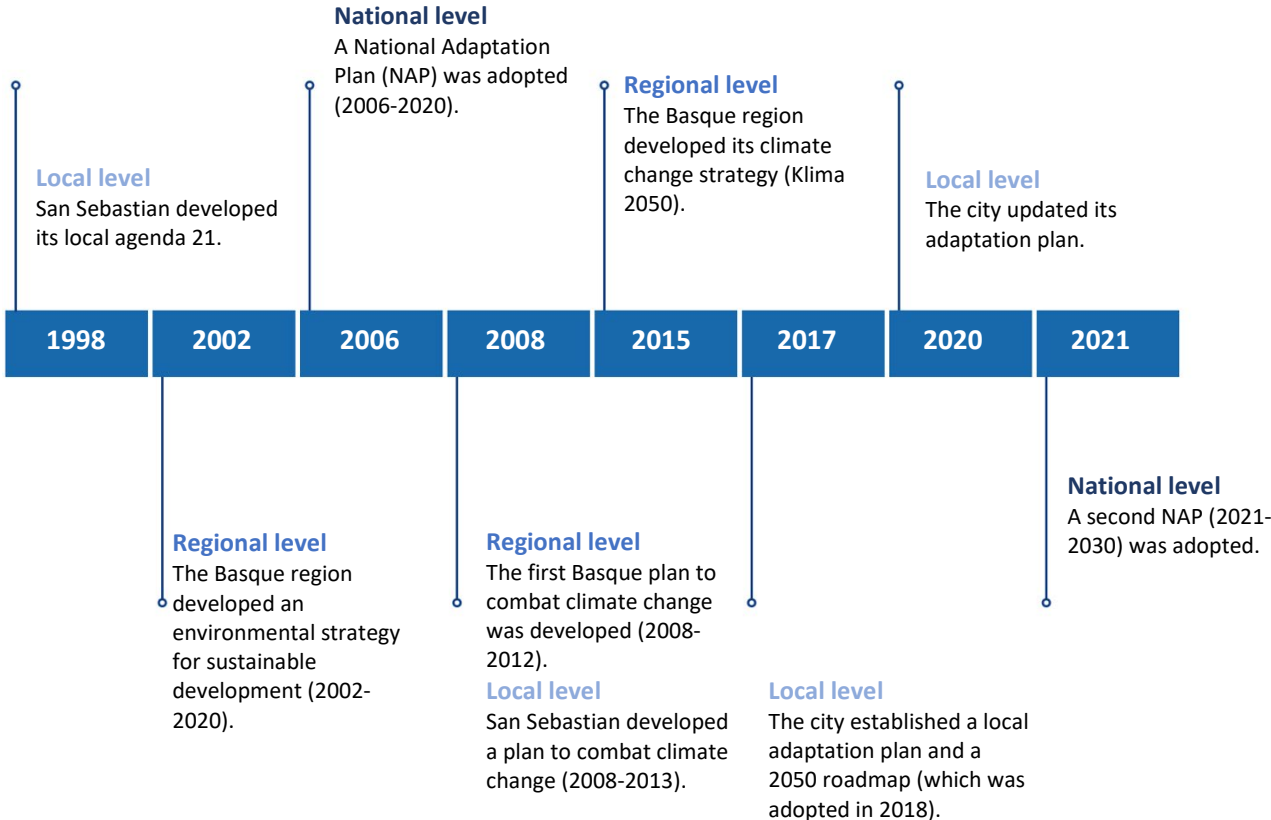


Figure 50 Timeline of strategy development at a national, regional, and local scale serving climate adaptation in San Sebastian.

4.5.3 Implicating and Mobilizing Actors: The establishment of a local technical commission for adaptation

The Basque Government (2015) asserted in its climate strategy that it aims at setting up the 'KlimaTEC' forum for the showcase of sample projects and the transfer of advanced knowledge among technology centers, companies, universities, and the administration to drive innovative solutions. It also wants to incorporate climate change variables in the training programs within the public sector and aims at setting up a 'Klima 2050' portal as well as awareness and communication campaigns allowing for the sharing of knowledge and expertise. The Basque Klima 2050 strategy presented the willingness of the regional government to develop interdepartmental coordination allowing for the evaluation of the effect of public action and the definition of necessary adjustments. Lastly, it underlined the aim of the Basque government in participating in international and inter-regional networks such as ICLEI, the compact of mayors, nrg4sd, the climate group, and others (Basque Government, 2015).

The Basque climate strategy (Klima 2050) aligns with EU targets and is the result of a process that started in 2014 affirmed an associate at the Public Society for Environmental Management of the Basque Government – Ihobe (interview, 2021). He explained that various climate specialists were involved in the development of this strategy including researchers and scientists at the University of the Basque Country. Additionally, all the ministries forming the Basque government were implicated in the definition and the drafting of the climate strategy to combine different sectoral plans into a single planning tool. The Klima 2050 (Basque Government, 2015) plainly stated that "the involvement of the different Ministries of the Basque Government has been essential in this process, and they have strived to mainstream climate change planning in the different sectoral policies". The Basque climate strategy is also the result of a cooperation between provincial and local councils along with civil society through several participation forums affirmed the associate at Ihobe (interview, 2021); adding, that "this has allowed for the definition of goals and plan of actions on the horizon 2050 and the prioritization of actions to be implemented by 2020".

An 'Environmental Framework Program' (EFP) was set to ensure the coordination of the course of environmental actions within the Basque government. The program has a twofold objective. First, it evaluates and translates EU policy at the scale of the territory. Second, it guides the actions of local administration in the prioritization and coordination of policies to be implemented in the following years (Associate at the Public Society for Environmental Management of the Basque Government, interview 2021).

To reach sustainable development goals at a regional scale, "Udalsarea" was established, a Basque network bringing together 200 municipalities (Associate at the Public Society for Environmental Management of the Basque Government, interview, 2021). Moreover, the Basque Center for Climate Change, known as the "BC3", bringing together 35 researchers from 12 different countries, is considered one of the most prominent and influential think-tanks in Europe and in the world in the areas of climate policy and economy. Its main goal is to integrate sustainable development within various fields and sectors of local councils (Associate at the Public Society for Environmental Management of the Basque Government, interview, 2021).

According to the Basque Government (2015) and as underlined in its climate strategy “Climate change is still unknown in many spheres of action” and various public and private actors still don’t know their roles in addressing the issue. This makes developing knowledge and raising awareness necessary to allow actors from different sectors to reduce their emissions and adapt to climate change. “Public awareness is a key aspect in climate change, not only for the ensuing actions to be carried out but also for the general public to understand the importance of climate adaptation and to moving towards a more adapted and resilient society”. (Basque Government, 2015). The engagement of citizens in the Basque country includes the development of possible private-public partnerships and the encouragement of citizens’ initiatives. For this purpose, the Basque government (2015) asserted in its Klima 2050 strategy that it aims at training, raising awareness, and informing the public about the issue of climate change. It also has the goal of leading by example and positioning itself on an international stage by limiting its emissions to zero. Lastly, it aims at strengthening inter-institutional coordination mechanisms to take appropriate climate actions.

The Basque government (2015) asserted in its climate strategy that the coordination of actions and policies could be particularly complex as it requires the involvement of many stakeholders working in an effective way. The regional government also underlined the importance of carrying out horizontal and vertical coordination (between the various departments in the county council, and along with the local councils) as the absence of appropriate coordination tools could hinder the achievement of the targets defined in the regional climate strategy (Basque Government, 2015). Therefore, the Basque Ministry of Environment and Territorial Policy, with support from the Ministry of Economic Development and Competitiveness, is responsible to guide the coordination as well as the regional climate strategy. Additionally, the Basque government (2015) avowed in its climate strategy that it plans on developing and implementing instruments facilitating the mainstreaming of climate policies in public planning.

In 2014, 19 municipalities in the Basque country signed the covenant of mayor’s initiative and San Sebastian committed itself to Mayors Adapt, additionally, the Basque Country joined the ‘Compact of Regions’ and committed to limit emissions and report its data yearly.

The city of San Sebastian participated in international programs such as the CIVITAS, a network of cities collaborating to develop improved and “cleaner” transport in cities. The city finds this program as an opportunity to develop its sustainable urban transportation strategy through maintaining and increasing the share of active transport systems such as walking and cycling (CIVITAS, n.d.).

The city of San Sebastian adhered to the Mayor’s Adapt initiative in 2014. By doing so, the city council voluntarily committed itself to develop a local adaptation strategy including climate impact and risk assessment, the development of an adaptation strategy, the implementation of adaptation measures, monitoring and evaluation, the preparation of an evaluation report, and the improvement of the strategies in place (City of San Sebastian, n.d.a).

In 2015, the city also willingly adhered to the compact of mayor’s initiative -a city networks agreement, to which the members commit to undertake a supportive and transparent approach at a municipal level to limit emissions, reduce vulnerability and increase resilience to climate change (City of San Sebastian, n.d.a). The initiative is based on pursuing climate objectives consistently and rigorously through reporting on progress and ensuring that the information is publicly available to favor the exchange of experiences (City of San Sebastian, n.d.a). Donostia/San

Sebastian is one of the few Basque municipalities that have been recognized by ICLEI for full compliance with the Compact of Mayors initiative, led by the networks C40, ICLEI, and UCLG cities worldwide (Feliú, et al., 2017).

In 2016, a Technical Commission for Adaptation of Donostia/San Sebastian - tasked to participate in the development of the climate change adaptation strategy of the municipality- was created by a decree from the mayor (Feliú, et al., 2017; San Sebastian Climate consultant 2, interview, 2021). The commission includes members from various departments working in areas impacting the environment such as Projects and Works; Sustainable Town planning; Prevention, Fire Fighting and Salvation; Maintenance and Urban Services; Promotion; Social Welfare; and Strategic Plan. It works on ensuring coordination of actions across various sectors and is responsible for supporting and encouraging all departments to align their policies to achieve climate commitments (San Sebastian Climate consultant 2, interview, 2021).

For the development of San Sebastian's climate change adaptation strategy, 3 workshops were organized bringing together municipal technicians (Feliú, et al., 2017). These technical meetings served to present and launch the adaptation plan to the member of the Technical Commission of Adaptation of the city council to define the context, phases, and scope of the study to be carried out (Feliú, et al., 2017).

"The city of San Sebastian is not really an industrial hub and does not have many large companies. The city has small businesses, and its economy is mainly based on tourism.", affirmed an Environmentalist at the San Sebastian City Council (interview, February 2021). He elucidated that there is one cement factory in the city that has a large carbon footprint, so the city has periodic meetings with it to ensure collaboration in the field of climate change. Additionally, when developing the local climate strategy 2050, the city met with the Gipuzkoa association of businessmen to introduce them to the issue and ensure collaboration (Environmentalist at the San Sebastian City Council, interview, June 2021). However, "this collaboration is more in the area of climate mitigation and air pollution, to limit the carbon footprint of businesses, rather than increasing their resilience to climate events" (Environmentalist at the San Sebastian City Council, interview, June 2021). Local businesses and the private sector are not involved in the development of adaptation strategies. Some companies, due to their own motivation, assume climate commitments (San Sebastian Climate consultant 1, interview, 2021).

The city has a sectorial environmental council - constituted of members of non-governmental organizations, a representative of each political parties and very few individual citizens - which has held a couple of meetings per year since the action plan has been carried out (Environmentalist at the San Sebastian City Council, interview, February 2021).

The city council has a participation department that is competent and is working on participatory budgets asserted San Sebastian Climate consultant 1 (interview, 2021). He added that there have been consultations on certain issues and projects, however, on the topic of climate action in particular the city does not work through participatory consultation; affirming "to date there is no formal procedure allowing for the participation of the public in the decision making or the implementation of adaptation measures".

A report (Veith, 2018) -developed by 'energy cities' introducing local energy and climate roadmaps of 5 European cities- affirmed that the roadmap to citizen's participation in San Sebastian emphasizes the importance of going beyond an open discussion or debate, including the intervention and commitments of citizens and local stakeholders in the decision-making process and the development of measures and policies. It asserted that "the development and implementation of San Sebastian's roadmap are about designing new forms of collaborative governance within the city by mobilizing the collective intelligence of its inhabitants" (Veith, 2018). The report (Veith, 2018) also clarified that the city of San Sebastian is reinforcing the distribution of accountability and responsibilities through encouraging the participation of informed and active citizens.

The city asserted in its climate action plan (Klima 2050) that cultural change is seen as the central element of any climate action, declaring, "like any cultural change, it is not possible to do it without public participation" (GEA21, 2018). The climate action plan also underlines that actors' participation is understood not only as opening the debate to citizens but also taking advantage of collective intelligence in the search for solutions (GEA21, 2018).

A photo contest "Donostia against climate change" was launched to receive the citizen's perception of climate change in the city. An exhibition was then organized and open to the public from the 24th of October until the 6th of November 2016, to display the award-winning photographs. Press releases and news about the contest were published to inform a larger number of citizens. This initiative acted as a tool to increase citizen's engagement and to raise their awareness to the issue of climate change asserted an Environmentalist at the San Sebastian City Council (interview, February 2021). He elucidated that "this was also helpful for us to see how citizens perceive climate change".

Additionally, in March 2019, the city hosted an 'International conference on climate change' in which various actors participated including the university of the Basque country, Udalsarea, BC3, ICLEI, nrg4SD as well as actors from the private sector.

In the opening of this conference, RTVE (the Spanish radio and television corporation) joined the 'Media declaration on climate change'- a decalogue of key recommendations when reporting on this global issue. Consequently, it developed a TV report presenting simulations and communicating to the public on the impacts of the sea level rise on the city of San Sebastian (RTVE, 2019). Broadcasting such reports could play an important role in sensitizing the public and developing their awareness to take climate action and limit the impacts of climate change as it presents in a dynamic and simplified way the scientific facts to the public elucidated a San Sebastian climate expert (interview, 2021). He, however, emphasized that it is crucial to make sure that the information conveyed to the public is truthful and adequate.

4.5.4 Implementing Developed Strategies: Improving knowledge and exploring opportunities

The San Sebastian's updated climate plan (Gutiérrez et al., 2020) sheds the light on the progress that has been made in the city in the execution of different actions since the development of the first adaptation plan in 2017. Many of the implemented actions are aimed at improving knowledge about the impact of the main climate threats on different spheres within the city.

The city of San Sebastian (n.d.a) communicated on its online platform that the understanding of the impacts of climate change on the infrastructure and critical services of the municipality as

well as the development of adaptation measures is important to increase the resilience of urban systems (e.g., telecommunications, energy, and water sanitation) to climate change. Consequently, an analysis is conducted to define how could a correct service be guaranteed to withstand extreme weather events (The city of San Sebastian, n.d.a).

Spatial information with high resolution were provided by the municipality of San Sebastian including exposure, land use, adaptive capacity, vulnerability, and risk maps on urban heat island effects and floods (Estreguil et al., 2019). A participatory modeling method (QUICKScan) was used to link decision-makers and stakeholders to available spatio-statistical data (Verweij et al., 2016). Workshops start with a simple knowledge-based approach, progressively adding complexity employing the interpretation of model results by participants (Estreguil et al., 2019). The developed maps, in addition to the view of participants, were converted into mental images of areas that are vulnerable to climate change. Impacts were listed followed by an array of options for adaptation measures as well as the possibility of their implementation (Verweij et al., 2016; Estreguil et al., 2019). Lastly, the effectiveness and the feasibility of the solutions were charted based on the agreement of various actors including policymakers, practitioners, and academics (Estreguil et al., 2019).

The developed map below (*figure 51*) presents the various possibilities to implement adaptation measures to increase the city's vulnerability to climate change as defined by the QUICKScan method. This allows defining the areas in which interventions are possible and feasible.

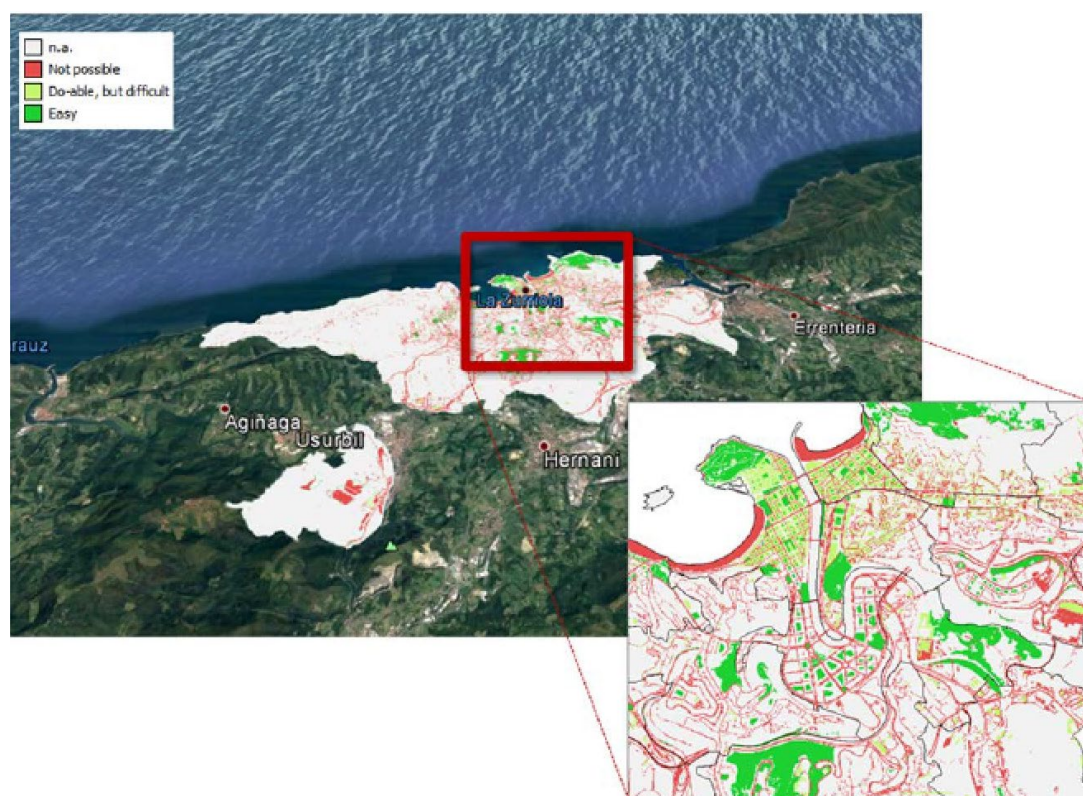


Figure 51 Possibilities for the implementation of climate adaptation measures in San Sebastian as defined by QUICKScan. Sources: Verweij et al., 2016; Estreguil et al., 2019.

The “SmartKalea” project was introduced in 2014 in the ‘Main Street’ (Calle Mayor) in the old town of the San Sebastian. The initiative, led by the Fomento de San Sebastián (The promotion of

San Sebastian), consists of a pilot project based on the implementation of smart solutions. Its objectives are to transform San Sebastian into a smart city, to achieve energy and economic efficiency, generate new opportunities for businesses, and raise awareness and foster citizen participation about sustainability and energy savings (Fomento de San Sebastián, n.d.).

As the initiative demonstrated good results in Calle Mayor, it was replicated in another street of the city (Fomento de San Sebastián, n.d.). The initiative was recognized with the 'Smart Cities Award' for 2015 granted by SOFINCO Foundation. It also received the 2017 CNIS (Congreso Nacional de Innovación y Servicios Públicos) award for the best public-private collaboration project (Fomento de San Sebastián, n.d.). Nonetheless, it is important to highlight that Smartkalea is more focused on energy efficiency and consumption reduction; yet presents an interesting tool that allows for sharing information and coordination among various actors.

The garden city of Loiola project was established to protect the area against possible floods. The project's aim is to revive this neighborhood which had many deficiencies for decades such as the unavailability of adequate lighting, the absence of sidewalks, and the lack of channeling for rainwater. The area was re-designed in 2014 through a process of citizens participation, emphasizing the criteria of equality, to create a safe environment. Three participatory workshops were organized to develop the proposal for the urban plan for the garden city of Loiola (Environmentalist at the San Sebastian City Council, interview, February 2021).

This project was presented in a press article (Munguía, 2019) as an initiative aiming at ending the urban discontinuity between Riberas and Loiola through the construction of 261 new homes and the generation of 6 000 sqm for tertiary use and the development of sports fields and green areas. The article (Munguía, 2019) clarified that delays in the implementation of the project occurred, however, in 2019 the municipal government stated that the garden city initiative is a priority and didn't want any more delays and expected the earthworks to begin in 2021.

The city of San Sebastian has shifted its views to see the Urumea river as an opportunity rather than a problem (Environmentalist at the San Sebastian City Council, interview, February 2021). Subsequently, the Urumea Channel was broadened from 25 meters to 50 meters in size along 500 meters to give room for the river and protect the area from flooding (Soriazu, 2020). To carry out the project, farmhouses, garages, and workshops were demolished, and the land was cleared to gain space for the river.

The Txomin Enea district, situated at the banks of the Urumea river, has been a victim of cyclical floods for decades. A study of thermal comfort and surface flooding has been carried out in this neighborhood and used as based as a basis for the management and rehabilitation of the area. Consequently, several scenarios were proposed with design alternatives to analyze their effectiveness in terms of temperature reduction and runoff reduction (Gutiérrez et al., 2020). The results of the Txomin Enea modeling study showed that the implementation of natural solutions such as trees, green roofs, fountains, bodies of water, as well as the permeabilization of the surface through permeable pavements, has positive effects on the reduction of the runoff water, the reduction of temperature and the improvement of the thermal comfort of the people (Gutiérrez et al., 2020). A submersible river park project, Parque fluvial Txominenea, was therefore developed to increase the resilience of this district to inundations through transforming the riverbank into an accessible floodable recreational area of 4 hectares protecting a new urban development -"new

Txomin”- providing 1300 new homes. The submersible river park (*figure 52*) aims to enhance the river and integrate Urumea into the urban development of Txomin.

“The city was lucky to be able to collaborate with technology centers to assure the necessary technological resources for the implementation of such projects” affirmed an Environmentalist at the San Sebastian City Council (interview, June 2021). He added, the Basque Water Agency and the Basque government were involved in the development of the channeling works, and financial support was received from the European Regional Development Fund (FEDER).



Figure 52 Aerial view of the submersible river park located between the new Txomin neighborhood and the river. Photo by: ALTUNA WOLF, El Diario Vasco.

San Sebastian has a huge number of urban green areas with easy access, presenting the green lungs of the city and a reflection of its sustainability. These parks include Mount Urgul which is in a high-density zone at the proximity of the city’s old quarter and the Miramón Park located in an industrial area (Gutiérrez et al., 2017). There are other parks that have existed for a while and are not particularly developed to ensure climate adaptation; however, they present themselves as nature-based solutions that currently exist in the city of San Sebastian (Environmentalist at the San Sebastian City Council, interview, February 2021). Around 30% of the area of urban squares is planted, which highlights that there is still room for improvement, especially that most of the planted vegetation is ornamental affirmed Gutiérrez, et al. (2017) in a methodological guide for the identification and mapping of Nature-based solutions for local climate adaptation in the Basque Country. Adding, “improving the spaces involves increasing the green surface that they occupy, increasing the density of the existing vegetation, installing water features that refresh the atmosphere, etc.” (Gutiérrez, et al., 2017). Some urban features, such as existing ornamental fountains in the city of San Sebastian, could present possible solutions to soothe the weather in times of high temperatures and heatwaves. However, if not appropriately managed, they could

imply water loss and energy consumption (Gutiérrez, et al., 2017). This underlines the importance of determining the implementation and maintenance cost of the intervention as well as the effectiveness of the solution.

The city has a competent team of technicians and employees working on environmental matters, affirmed an Environmentalist at the San Sebastian City Council (interview, February 2021). However, “the city needs more staff to ensure the implementation of environmental and adaptation initiatives” he elucidated, “hiring more people leads to additional expenses and costs and, at the moment, the city can’t afford it”.

In Spain, there is a transparency law obliging to make municipal accounts public (Environmentalist at the San Sebastian City Council, interview, February 2021). In respect to this law, the city of San Sebastian presents its annual budget on its official website. The public has access to the city’s financial plan from 2011 until the current year. This increases the city’s transparency and permits citizens to recognize the sources of income as well as the city’s expenditure.

The city is gradually increasing the budget dedicated to environmental projects. In 2018, this budget stood at 12.89 M euros, the following year, it reached 13.7 M euros (The City of San Sebastian, n.d.b). However, it is important to highlight that the city’s total budget for 2018 and 2019 stood at 444.9 M euros and 467.4 M euros respectively (The City of San Sebastian, n.d.b). This means that the environment’s expenditure only increased from 2.897% (2018) to 2.93% (2019) of the city’s total budget. This percentage is exceptionally low and is proof that the city’s budget dedicated to environmental initiatives is small. The areas and sectors that are responsible for the largest expenditure of the city’s budgets are town planning, wellness, security, culture, and public transport.

As implemented measures are at an embryotic stage, it is hard to determine if the various projects implemented at a local scale have directly reduced the exposure of the city to climate risks, however, these projects have sure allowed increasing the city’s adaptive capacity and its resilience to deal with climate events (San Sebastian climate expert, interview, 2021).

An environmentalist at the San Sebastian City Council (interview, June 2021) highlighted that there is still a lot of work that should be done, and many resources are needed to ensure the implementation of climate action and adaptation plans. The city is actively working to obtain financing lines. At the European level, it is participating in the LIFE Integrated Urban Klima 2050 project and two projects are being prepared for submission to European Funds. At a supra-municipal scale, the city has accessed lines of grants for sustainability actions from the Provincial Council of Gipuzkoa (Gutiérrez, et al., 2020).

4.5.5 Monitoring and Evaluation: Smart technology to assess mitigation efforts and qualitative approach to evaluate adaptation

In 2018 and 2019, the Spanish Office for Climate Change carried out a thorough evaluation work on the National Plan for Adaptation to Climate Change, to identify the progress made, the unresolved challenges, and the lessons learned to date. The evaluation process included conducting interviews and surveys as well as the opinions and suggestions of professionals in the

field. A series of monitoring and follow-up reports of the national climate adaptation plan were produced in 2008, 2011, 2014, and 2018 respectively to update the work program.

The Natural Environment and Environmental Planning Directorate is supported by the Basque water Agency and the environmental management agency to monitor and evaluate climate policies at a regional scale. The Basque government (2015) highlighted in its climate strategy that periodic monitoring of the line of actions as well as their impacts need to be determined and affirmed that the set of actions is to be reviewed and updated on a 10-yearly basis. To allow for this monitoring at a regional level, the Basque country developed a “datasheet of the degree of compliance of the actions” (Basque Government, 2015). This sheet determines the measures to be taken and for each measure, the person in charge and the departments involved to encourage its implementation as well as the allocated budget. It allows for the comparison of the obtained results over time with the established objectives of the strategy.

The Basque country committed itself to develop monitoring reports on a two-yearly basis as of 2017. These reports will identify the degree of progress and the enactment of the actions specified for each period of implementation (2020-2030, 2030-2040, and 2040-2050). It also committed itself to develop “Interim assessment reports” every ten years as of 2020. These assessment reports will allow to determine any deviation from the set goals and develop respective corrective measures affirmed the associate at Ihobe (interview, 2021). An external independent entity is set to prepare these reports following the principles of cooperation, participation, and transparency asserted the Basque government (2015) in its climate strategy. The Udalsarea collects data from the 200 municipalities that are part of this network to ensure the monitoring and evaluation of municipal environmental policies (San Sebastian climate expert, interview, 2021).

Additionally, some sectoral reports or analyses may be required and produced to accompany existing reports. The regional Environmental Planning Directorate will coordinate all these reports. The participation of socio-economic stakeholders and of the public in the monitoring and evaluation process of the regional climate strategy in the Basque country is considered. Sessions are planned to be organized to present the progress to the public to invigorate the processes. Some forums such as Klima-Tec, the Basque Government portal, and Udalsarea network will allow and encourage public participation (Basque Government, 2015).

The “SmartKalea” project aims at promoting energy efficiency, environmental sustainability, and citizen participation through monitoring and developing indicators that help in the management of the city (Fomento de San Sebastián, n.d.). This smart tool allows determining the “city’s sustainability level” which is measured on daily basis in two neighborhoods: Parte Vieja and Altza. For instance, the water consumption is monitored per square meter in commercial centers and households participating in this initiative via smart meters. The daily consumption is analyzed to develop an understanding of the actual situation, determine water needs and assure the development of appropriate water policies. The flow of pedestrians, the renting of bikes, and the number of passengers using public transport are also monitored in these two neighborhoods. In the light of the SmartKalea project, sensors are installed in the Cervantes square allowing to measure the level of solar radiation. This index indicates the intensity of UV radiation which could lead to skin damages. This information could thus protect citizens from harmful radiation, particularly in times of extreme heat (Formento de San Sebastián, n.d.). However, these indicators

are only particular to the neighborhoods Parte Vieja and Altza as it is a punctual experimental initiative, that might be scaled up in the future. The water and electricity consumptions are only measured in participating households and commercial stores, which is not representative of all the habitants or shops in these two neighborhoods. Also, the indicators are not particular to climate adaptation and do not directly or clearly identify the progress in the implementation of adaptation measures.

The city has a model of evaluation and monitoring of local sustainable development policies that are conducted by the city council on a yearly basis (San Sebastian climate expert, interview, 2021). Municipal departments are responsible to report to the city council on the progress of specific actions. The city council then evaluates progress based on a qualitative analysis of the degree of compliance in the execution of planned adaptation actions (San Sebastian climate expert, interview, 2021; Environmentalist at the San Sebastian City Council, interview, February 2021).

The city also surveys minimum temperatures, maximum temperatures, the number of trees that have fallen due to episodes of strong wind (Environmentalist at the San Sebastian City Council, interview, February 2021). However, these quantitative indicators are more relative to assess the evolution of weather events and their manifestation in the light of climate change and are not particular to assess the development of adaptation efforts.

The technical commission of adaptation meets a couple of times per year (San Sebastian Climate consultant 1, interview, 2021), to supervise the actions that have been implemented, what measures need to be adjusted (Feliú, et al., 2017). It also promotes actions and future response mechanisms reducing the risks arising from climate change and works on keeping the adaptation strategy up to date (San Sebastian Climate consultant 1, interview, 2021).

The city still has to work on systemizing monitoring and evaluation (Environmentalist at the San Sebastian City Council, interview, February 2021).

4.5.6 Understanding Success and Limiting Factors: Efforts to innovate and create synergies challenged by the need for cultural and behavioral changes

The Basque Government (2015) asserted in its climate strategy that one of the challenges of raising new adaptation needs is the uncertainty and the lack of knowledge regarding the impacts of climate change.

The Basque Government (2015) identified short-term priority actions including the improvement of expertise and knowledge to enable an enhanced decision-making process. It considered that the starting point to improving the knowledge is to adapt the scale of the studies utilizing regional climatic models to ensure a higher level of detail on climate projections (Basque Government, 2015). It also highlighted the necessity to effectively implement climate policies in the region, create synergies, drive the economic prosperity of climate and energy investments, and maximize the efficiency of resources so that addressing climate issues would be perceived as a competitiveness factor rather than a burden.

The SmartKalea project makes the results of monitoring publicly available and accessible through the website⁶⁷, allowing for an informed decision making at the level of households, private

⁶⁷ <http://www.fomentosansebastian.eus/smartkalea/en/monitoring>.

corporations, and local governments. In addition, reports, and comparative analysis were produced for the years 2017 and 2018 and published. In the energy and water sections, household and commercial consumption are analyzed making annual and weekly comparisons, observing the evolution, and drawing patterns in Calle Mayor and Paseo de Altza. For instance, the evolution of water consumption allowed to confirm that the average annual consumption has increased from one year to another, and a remarkable increase is registered in touristic summer months. The data also allows to determine peak consumption hours (Formento de San Sebastián, n.d.). These observations, made possible through monitoring, allows policy makers to develop a thorough understanding of the situation and be able to tackle specific issues through developing corresponding measures (e.g., raising public awareness, proposing measures to promote sustainable tourism, developing incentives to reduce the pressure on water consumption particularly during peak hours to limit draught risks, among others.)

The city publishes the monitoring and evaluation results of mitigation, however, in terms of adaptation the city has not really done so as the monitoring and evaluation system in place needs to be developed (Environmentalist at the San Sebastian City Council, interview, February 2021). The city's updated climate adaptation plan (Gutiérrez et al., 2020) shed the light on the progress that has been made in the implementation of different actions since the development of the first action plan (i.e., between 2017 and 2020) and defined the gaps or the areas that need to be addressed.

San Sebastian's climate action plan (GEA21, 2018) highlighted that climate change presents an added difficulty with respect to other social and environmental challenges for its full incorporation into social consciousness: it is relatively invisible in the day-to-day. It elucidated that the scientific climate discipline handles probabilistic estimates and time scales of difficult assimilation in other frames of thought, making it excessively abstract and away from everyday life. In addition, there seems to be a contradiction between the times of climate change and the times of cultural change (GEA21, 2018).

The location of San Sebastian on the coast increases the pressure to adapt it to climate change and requires high investments for the development of adequate infrastructure protecting the city from the rise of sea levels (San Sebastian Climate consultant 2, interview, 2021). Finding the appropriate financial resources for the implementation of adaptation measures could therefore be a challenge (San Sebastian Climate consultant 1, interview, 2021). The financial issue is an important barrier as it also impedes the availability of human resources at the scale of the city affirmed an environmentalist at the San Sebastian City Council (interview, June 2021). He added, in terms of climate action, the city is doing what it can do to assure energy efficiency, however it can't directly control what citizens are doing. Some incentives are in place to invite people to take climate action such as bonuses for vehicles that are less polluting and for energy efficiency building rehabilitation, however, it remains a challenge to influence citizens' behaviors (Environmentalist at the San Sebastian City Council, interview, February 2021).

According to the city's climate action plan (GEA21, 2018), Donostia/San Sebastian has been a European reference in some urban quality policies; an example from which other cities want to learn. That pride is an incentive for the city to continue being a reference for other cities in the area of mitigation and adaptation to climate change (GEA21, 2018). Both interviewed San

Sebastian Climate consultants (1 & 2) as well as the Environmentalist at the San Sebastian City Council affirmed that the municipality has a competent team of experts that are supporting the development and the implementation of adaptation strategies. “This team is always open to participating in innovative projects and has the willingness to put the city on the map as a pioneer in addressing environmental issues” (San Sebastian Climate consultant 2, interview, 2021). The technical commission has been playing an important role in creating synergies, ensuring coordination between various departments as well as alignment between implemented measures and the city’s long-term ambition (San Sebastian Climate consultant 2, interview 2021).

The adaptation measures in place have allowed to slightly increase the resilience of the city to climate events, yet more effort is required asserted an Environmentalist at the San Sebastian City Council (interview, February 2021). He added that the city has been mostly focused on carrying out studies and developing knowledge which is crucial for taking appropriate actions, yet “the city should now give an increased attention to the implementation and scaling up of adaptation measures and to developing a more complex monitoring and evaluation system (Environmentalist at the San Sebastian City Council, interview, February 2021).

4.5.7 Improving the Governance System in Place: Preparing for extreme events and developing local plans for food emergency and forest fires

The Basque government (2015) elucidated in its climate strategy that climate change is not a static phenomenon and depends on the economic, social, and technological evolution as well as on anthropogenic factors, and therefore aims at developing knowledge and coordination in the lines of research. Through its plan of actions, the Basque government aims at continuing its progress in improving the understanding of future climate scenarios as well as the evaluation of their impacts on ecosystems as well as the various economic sectors (Basque Government, 2015).

Developed in 2015, the Basque climate strategy fixed sets a timeline at the horizon 2050 with an initial period for the implementation of policies between 2015 and 2020 (Basque Government, 2015). The regional government highlighted that at the end of this initial period, the degree of progress of actions as well as the envisioned objectives will be evaluated along with the implementation of interdepartmental and inter-institutional measures. This will allow redefining the actions in 2020 for a 2nd implementation period from 2020 until 2030 (Basque Government, 2015). This demonstrates the flexibility of the regional’s government approach to climate action based on new perceptions and insights.

In its climate strategy, the Basque countries identify 9 general goals including adaptation objectives for the horizon 2050, such as: anticipating the risks, increasing the resilience and the efficiency of the territory, increasing the resilience of the natural environment, leading to improvement, innovation, and knowledge transfer as well as adopting an exemplary governance system (Basque Government, 2015).

The Basque government (2015) affirmed in its climate strategy that, on the horizon of 2050, it has the objective to drive a compact urban structure that is resilient to changes in climate. It also aims at integrating climate adaptation and vulnerability analysis in territorial and urban planning as well as incorporating climate change variables in the management of coastal areas (Basque Government, 2015). The Basque government has a goal of guaranteeing water supply for different uses in the long term. It also aims at ensuring the resilience of critical infrastructures (e.g., ICTs,

health, water, food, and energy) and the built environment to extreme events (Basque Government). The regional government aims at communicating and improving scientific knowledge and promoting innovation. Additionally, it seeks to implement a system to monitor and evaluate the impacts of climate change on the region (Basque Government, 2015).

An “Environmental Framework program (EFP) 2020” was published in 2014. As part of its drafting process, the implementation progress of the Basque Environmental Strategy for Sustainable Development (2002-2020) has been reviewed affirmed an associate at the Public Society for Environmental Management of the Basque Government (interview, 2021). He clarified that the review served as a basis to provide an environmental framework with a long-term strategic perspective, bringing new insights and allowing for the establishment of new targets for 2030 and 2050 based on current experience.

The San Sebastian climate action strategy sets out general objectives for 2050, including the reduction of GHG emissions by more than 80% through developing objectives in various sectors including the built environment, land use, transport, waste management, and energy (GEA21, 2018). The developed long-term strategy is not to be updated every couple of years as it sets the guidelines, but it could be reviewed in a period of 10 years. Having a long-term strategy, however, assures the flexibility of short- and medium-term adaptation plans. The implementation and development of measures are reviewed and adjusted based on acquired knowledge (Environmentalist at the San Sebastian City Council, interview, February 2021).

As of 2020, the city is aiming on reviewing the General urban planning strategy considering climatic criteria and on defining and applying criteria and climate regulations in the urban license management and activity (GEA21, 2018).

The possibility of implementing nature-based solutions in San Sebastian is being investigated. In the report “Nature-based solutions for local climate adaptation in the Basque Country”, current and potential nature-based solutions were mapped in the city. The city investigated the effectiveness, risks as well as adaptation potential of this approach (Gutiérrez, et al., 2017).

San Sebastian is actively working on developing new knowledge but has no plans to periodically updates its climate diagnosis based on an established frequency as it does not know how the knowledge will evolve; “this depends largely on financing resources and collaborations opportunities with research centers and city networks” (Environmentalist at the San Sebastian City Council, interview, 2021).

The city is currently working closely with technology centers to develop forecast studies and upon the generation of new knowledge, the diagnosis will be completed progressively and updated (Environmentalist at the San Sebastian City Council, interview, February 2021).

In November 2020, the city updated its adaptation plan based on a review of the previous plan (published in 2017), to make the necessary adjustments so that it continues to be a useful tool that guides municipal action in the field of climate adaptation (Gutiérrez et al., 2020). An environmentalist at the San Sebastian City Council (interview, February 2021) highlighted that the adaptation plan is to be continuously updated based on new insights and information, but the frequency of the update is not necessarily consistent.

The new plan (Gutiérrez et al., 2020) presented 33 actions, of which 19 come from the plan approved in 2017, 4 have been reformulated and 7 new ambitions have been proposed including:

1- Developing a city with a better climate culture. This includes reinforcing climate awareness and communication with the citizens on the impacts of climate change on their city, exploring new economic opportunities and markets derived from climate change, elaborating a biannual report to shed the light on implemented actions and progress in terms of adaptation, as well as the promotion of the use of the DSS Klima Adapt mobile application (Gutiérrez et al., 2020). The latter was developed to inform both municipal technical staff and citizens about river levels, air quality, meteorology, temperature, wind, and tide data. This application is supported by the ministry for ecological transition and the biodiversity foundation. The improvement of access to information through this application will allow for a better response in cases of emergency (The City of San Sebastian, n.d.a).

2- Ensuring internal organization and a local administration for the climate. This ambition relies on the consolidation of the interdepartmental commission for climate adaptation, the reinforcement of the search for sources of funds as well as the articulation of a formation plan in terms of adaptation addressed to different municipal departments (Gutiérrez et al., 2020).

3- Developing an urban design including building codes that are climate-sensitive. This goal necessitates the incorporation of adaptation criteria in studies specific to the local urban plan and the incorporation of design criteria to foster green solutions. It also includes the development of studies of climate comfort and inundation at a microscale as well as the realization of wind and air movement studies (Gutiérrez et al., 2020).

4- Preventing heating through the elaboration of thermal maps to identify critical points, the systemization of the treatment of climate data and the analysis of its impacts on health, and the revision of the existing protocol against risks of fires (Gutiérrez et al., 2020).

5- Creating a greener city through increasing the area of green and permeable surfaces and supporting the greening of roofs and balconies. Additionally, the city seeks to analyse the impact of increasing temperatures on biodiversity, elaborate green maps, and create comfortable green walking areas (Gutiérrez et al., 2020).

6- Ensuring the protection of the city from the rising sea levels. This ambition requires the maintenance of existing infrastructure exposed to the rise of sea level, a periodic actualization of existing emergency protocols in place in cases of inundations, developing studies on the effects of the rise of sea level on beaches and tourism, as well as taking appropriate decisions based on developed studies (Gutiérrez et al., 2020).

7- Protecting the city from floods through addressing the risks of fluvial floods, implementing sustainable urban drainage systems (SUDs), and coordinating with public agents competent in the management of areas that are exposed to inundations. The city is also aiming on improving knowledge in relation to coastal floods and updating the existing sanitation system (Gutiérrez et al., 2020).

The city can't be fully prepared to deal with unexpected weather-related events, but it is working in this line to build resilience through developing and fostering emergency plans affirmed an environmentalist at the San Sebastian City Council (interview, February 2021). The city's website

presents a flood emergency plan and a municipal plan against forest fires in Igeldo⁶⁸ (The city of San Sebastian, n.d.c).

The city's website provides live data of the river Urumea at two critical points, Txomin Enea and Martutene. Moreover, a mobile application is developed to provide data on Urumea rivers including water levels and water temperatures. Also, citizens could sign up for the SMS notification service, to receive necessary information in case of floods via SMS (The city of San Sebastian, n.d.c). The municipal plan against forest fires in Igeldo defines the set of municipal actions to be carried out. It also establishes various prevention measures, warning systems as well as intervention procedures. Lastly, the plan determines measures to restore the situation (the city of San Sebastian, n.d.c).

The intervention against forest fire is led by the Forest Service in collaboration with various entities such as the municipal guard, the help of residents, civil protection agencies, and the red cross (The city of San Sebastian, n.d.c).

4.5.8 Assessing the Urban Climate Adaptation Governance of San Sebastian

The data - collected based on the review of various documents and the conduction of interviews with different key stakeholders in the city of San Sebastian (*presented in sections 4.5.1 – 4.5.7*) - allowed to answer the set of 50 close-ended questions that were presented in the methodology (section 3.6.1) forming the climate adaptation governance index.

The application of the developed index to the city of San Sebastian has shown that the assessed city has favorable climate adaptation governance with a value of 8.4/10 (*refer to appendix III – table 16*). This means that the local government is actively working on improving the adaptive capacity of the city through the development of corresponding adaptation strategies based on the understanding of local climate impacts and vulnerabilities. Nevertheless, the fact that San Sebastian has a favorable urban climate adaptation governance system does not mean that it is exempted from dealing with unfortunate weather events; yet shows the preparedness of the city due to governance efforts to deal with extreme weather events, recover rapidly and find opportunities following the occurrence of these events.

The figure below (*figure 53*) presenting the adaptation governance efforts of the city of San Sebastian underlines that the city has a great understanding of impacts and vulnerabilities and has developed corresponding adaptation strategies, yet still has to boost its implication and mobilization of actors, invest more in the implementation of developed strategies, and ensure the development of a thorough monitoring and evaluation system to improve its climate governance.

The application of the climate adaptation governance index (*detailed in appendix III-table 16*) underlined that San Sebastian has a solid foundation for adapting the territory based on a thorough understanding of impacts and the development of corresponding adaptation strategies. Nevertheless, it could further involve the local community as well as the private sector and local businesses in the development and implementation of its adaptation strategy to improve the city's adaptive capacity and increase its urban resilience. The results have also shown that making

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<https://www.donostia.eus/info/ciudadano/planesalerta.nsf/fwHome?ReadForm&idioma=cas&id=A336670442424>.

adequate financial and human resources available for the implementation of adaptation strategies as well as ensuring that the civil society and the local community play a role in supporting and enhancing the implementation of adaptation measures play a crucial role in improving the city’s climate adaptation governance efforts. Additionally, the development of a thorough monitoring and evaluation system allowing to assess the progress of the city in the area of climate adaptation is important. Lastly, the results demonstrated that to boost its climate resilience and assure the improvement of the adaptation governance system the place in San Sebastian, impact and vulnerability assessments are to be updated periodically to integrate new findings and insights.

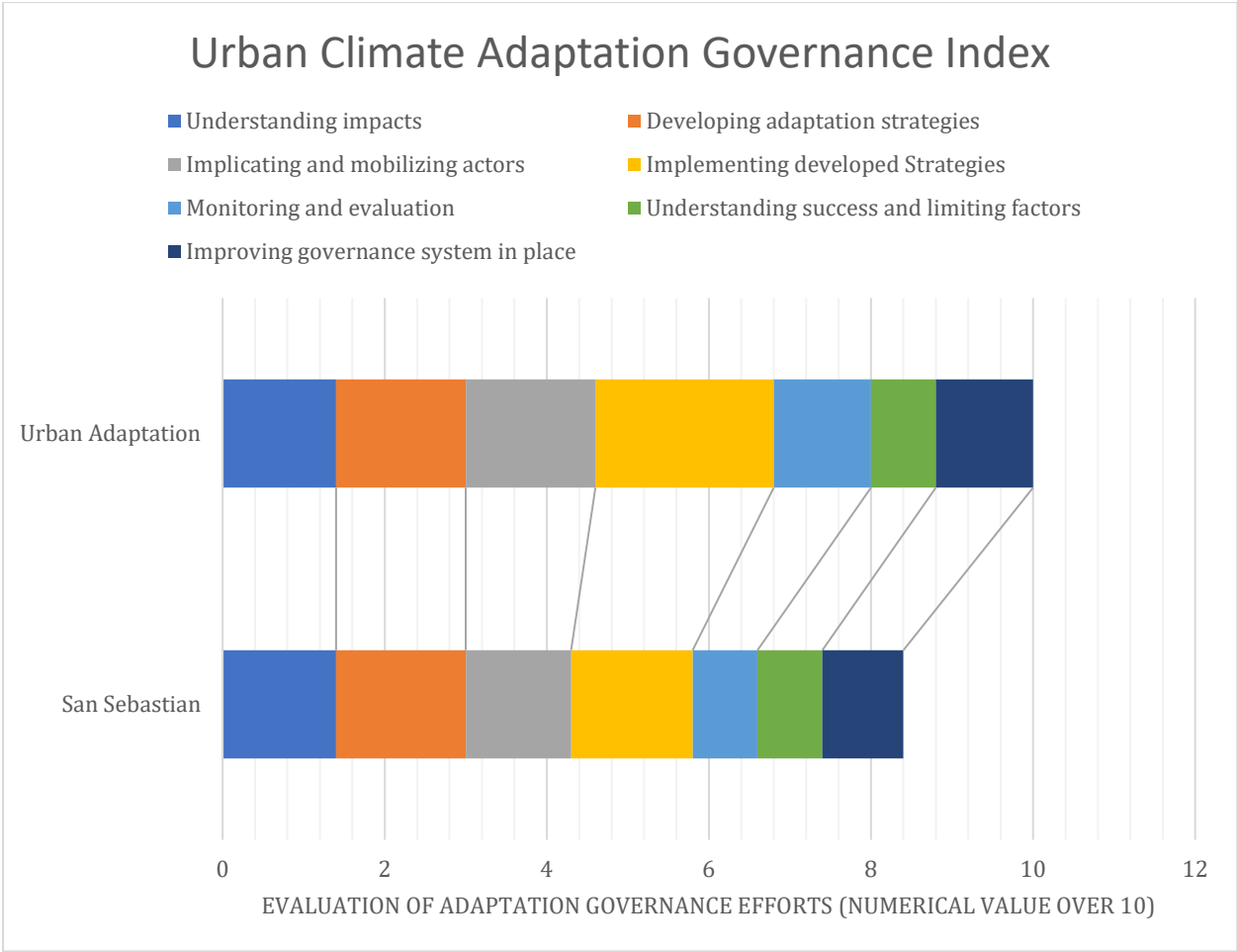


Figure 53 Visualization of the index score of the City of San Sebastian across various areas of climate adaptation governance.

CHAPTER 5: COMPARATIVE ANALYSIS

Because of their comparable scale, position, and adaptation goals to be reached, the five cities, Rouen, Nijmegen, Leuven, Växjö, and San Sebastian, were selected as case studies. The selection criteria included being a mid-sized European city that is committed to adapting to climate change, that is part of a climate or an environmental city network allowing it to share knowledge with other cities, and that has received an environmental award. Based on these selection criteria, the examined cases could be considered pioneers in adaptation in comparison to other cities of a similar scale. This comparative analysis thus allows to develop an understanding of what motivated these cities to engage in adaptation efforts, to determine challenges that are shared across the selected cities, and to conclude success factors. This could inspire other European cities of comparable scale to engage in addressing environmental issues. “Even if adaptation challenges are local and specific, solutions are often widely transferable and applicable on a regional, national or transnational scale” avowed the European Commission (2021) in its new EU Strategy on Adaptation to Climate Change.

The selected case studies present some differences that could affect their climate governance efforts. For instance, the Swedish city of Växjö and the Dutch case of Nijmegen are both located in decentralized countries and present examples in which local municipalities have important responsibilities and assume a wide range of competencies. Meanwhile, the French case of Rouen is an example of a city located in one of the most centralized developed countries (Samuel, 2017). Both San Sebastian and Leuven are examples in which regional authorities enjoy a great deal of independence and have important competencies. These divergences between centralized and decentralized systems could affect the power of decision-making and planning at a municipal scale. The competencies related to developing legislation, endorsing environmental plans, designing, and implementing adaptation measures thus vary according to the governance system in place and the respective territorial scope of each level of governance.

The observed similarities and differences between the examined case studies are presented below and organized according to the 7 areas of focus in the governance of climate adaptation defined in the developed conceptual model (section 3.4).

5.1 Understanding Impacts and Vulnerabilities: Collaboration with local experts and universities to bridge knowledge gaps, map vulnerabilities and raise public awareness

In the examined cases, municipalities have teamed up with research institutes, universities, local experts, or environmental NGOs to improve climate knowledge at a local scale. For instance, the city of Leuven and the city of Nijmegen developed a close working relationship with the University of KU Leuven and the University of Radboud respectively. Similarly, the city of Växjö is working closely with experts from the academic world and Linnaeus University. Setting up collaboration agreements and funding adaptation-relevant research could thus contribute to increasing the adaptive capacity of cities based on an improved understanding of climate impacts as university-government research collaborations assure knowledge-based innovation (Abbas et al., 2019). This was also underlined by the Belgian National Climate Commission (2017) in its seventh national

communication which emphasized the need to support innovation and research from a bottom-up perspective as most climate research takes place in universities and research institutes.

The city of San Sebastian is collaborating with local research and technology centers (Tecnalia and ADOS) among others to produce knowledge at a local scale. This presents the possibility for local municipalities to partner up with climate experts from the private sector for the development of diagnostic reports determining the impacts of climate change at a local scale. The metropolitan area of Rouen established a local IPCC bringing together a team of experts from various fields to identify knowledge gaps in the field of climate action and address them. This introduces the opportunity of setting up a local scientific climate committee to improve the understanding of local climate risks and investigate ways to address this global issue at a local scale. “The need for a foundation of knowledge about local vulnerability and impacts represents an opportunity for a fruitful two-way exchange between climate change scientists and impact experts on the one hand, and local and national decision-makers on the other” (Hallegatte & Corfee-Morlot, 2010). It is nevertheless important to underline that in all the examined cities, the collaboration of local authorities with experts from the academic and the private sphere to understand and address climate-related issues seem to be more focused on mitigation and sustainable development rather than adaptation. This stresses the importance of concentrating research and studies on the need and the potential of climate adaptation approaches at a local scale.

In the cases of Rouen and Leuven, there is still a knowledge gap and a need to improve the understanding of the impacts of climate change at a local scale. In these cases, vulnerability and impact assessments are mainly conducted at a national and regional level. For instance, a study on the impacts of climate change on the Norman territory was developed by the General Secretary of Regional Affairs and was used as a base for the decisions taken at the scale of Rouen. Similarly, the city of Leuven relied on the ‘MIRA climate report’ developed by the Flemish environmental agency determining observed and future climate changes at the scale of Flanders.

Hallegatte & Corfee-Morlot (2010) asserted that bottom-up, local assessments are crucial for informing cross-scale decision-making. This thesis showed that, indeed, examined mid-sized cities which are at the forefront of adaptation efforts, having showed favorable climate adaptation governance systems in place (based on the numerical value of the adaptation governance index), have, through various means, developed a more exhaustive understanding of the impacts of climate change at a local scale.

For instance, in Växjö, a risk and vulnerability analysis (RSA) was developed to identify the impacts of climate change at the scale of the city. The RSA builds on the knowledge acquired at a regional scale yet provides knowledge particular to the city of Växjö. This stresses the importance of profiting from the knowledge produced at a regional scale and going a step further to examine the impacts of climate change at a city scale. Especially that regional vulnerability reports tend to be more general determining the impacts of climate change on a wider scale, including territories of heterogeneous profiles in terms of population and size. In other terms, some municipalities within the region are urban, others are rural, and they are differently impacted by climate change (e.g., cities are at a higher risk of urban heat island effect while rural areas to deal with other impacts such as the effect of a changing climate on agriculture).

In the cases of Nijmegen and San Sebastian, thermal and flood maps were developed allowing to identify the vulnerable parts of the city. The mapping of vulnerabilities underlines the specificity of the urban context and determines the areas of priority for potential adaptation interventions. The

UrbClim model used to develop a thermal map allowed to determine indices including the duration of heatwaves, their frequency and intensity and these indices were crossed with socio-economic indicators to support decision making and identify areas of priority (Gutiérrez, Mendizabal, & Feliú, 2019). Comparably, delta scenarios presented in the case of Nijmegen developed maps and models displaying geostatistical data while considering demographic factors (e.g., population growth, aging, and income per capita) as they affect the vulnerability of society to stresses. These models could also consider the presence of critical infrastructures such as electricity, transportation systems, and information communication technology systems which make societies more vulnerable to disruptions (Ligtvoet, et al., 2015). This shows that the mapping of vulnerability to climate change requires a multi-layered approach taking into consideration the resilience of living beings (i.e., humans, flora, and fauna), as well as built systems to overcome climate events.

All five examined case studies are already dealing with the impacts of climate change, including urban heat island effect and heatwaves, drought, and floods (whether due to heavy rains, the rise of sea level, or fluvial floods – depending on the geographical situation). Yet, the intensity and frequency of these events vary from one city to another.

The comparative analysis shows that cities that have historically experienced stress seem to have an improved understanding of the impact and its ramifications on the various sector as well as a higher capacity to adapt to it, while newly experienced stresses or projected risks as well as their socio-economic ramifications in the light of climate change seem to be more complex to comprehend. Interviews conducted with local actors have shown that due to historical floods, Nijmegen, Leuven, and Växjö have developed the know-how and ways to address related issues. In these cases, protective and response measures were taken in the context of heavy floods even prior to developing an understanding of the impacts of climate change.

According to the interviewees, heatwaves seem to be more alarming to the public than cold weather and flood events since the latter is not necessarily seen as a manifestation of climate change and is rather considered a natural climate event (Municipality of Rouen employee in charge of ecological transition, interview, 2019; Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Not to mention, the interviews revealed that residents of these cities are generally better equipped for cold rather than warm weather. This underlines that, even cities which are considered at the forefront of adaptation efforts, need to develop an improved understanding of climate projections, raise public awareness, and build preparedness in respect to anticipated risks.

Various city actors in San Sebastian became increasingly aware of the threat of rising sea levels due to high waves that hit the city in 2014 (San Sebastian Climate consultant 1, interview, 2021). Similarly, the climate awareness of different stakeholders in Rouen increased following episodes of heatwaves (Municipality of Rouen employee in charge of ecological transition, interview, 2019). Climate awareness is still not a constant for many. “The climate concern comes in waves; sometimes the public forgets about it, especially when the impacts are not felt, other times, the public is reminded, especially after the occurrence of the extreme weather events” (Municipality of Rouen employee in charge of ecological transition, interview, 2019).

This shows that the impacts of climate change are still abstract or impersonal to many. This makes it particularly challenging to engage the public in the issue of climate change (Adger et al., 2003, Scannell & Gifford, 2011) and underlines the importance of vulgarizing environmental reports and

produced knowledge related to climate change to reach a wider audience. In San Sebastian, for instance, the city hosted an ‘International conference on climate change’ to mobilize various actors. In the opening of this conference, some media platforms joined a declaration on a decalogue of key recommendations when reporting on this global issue. This example illustrates the role of media in the vulgarization of climate-related knowledge. Other initiatives were also developed in the examined cities to raise public awareness. For example, the city of Växjö celebrates yearly the “Earth Week” in March (a prolonged version of “earth hour”) and takes this event as an opportunity to raise climate awareness by organizing dialogues and events with NGOs, companies, and citizens (Member of the Växjö climate commission, interview, 2020). Similarly, the city of Leuven was motivated to organize an annual Leuven 2030 Congress as of 2020 (Alderman in the board of mayor at the city of Leuven, interview, 2020). The city of Rouen established the “atelier cop 21” initiative to exchange knowledge and organize activities related to the environment and climate change.

The literature review introduced in section 2.4.2 on the role and importance of adaptation platforms which present ‘enabling environments’ offering climate knowledge and allow for peer-to-peer learning opportunities (Palutikof et al., 2019). Results have shown that indeed, some governments engaged in adapting to climate change such as the Dutch, the Swedish, the Basque, and the Flemish governments have established knowledge portals bringing together various actors, providing information about the evolution of climate conditions, and allowing for the transfer of knowledge.

5.2 Developing Adaptation Strategies: Local commitments -triggered by emergency- presented in various policy documents

Hallegatte & Corfee-Morlot (2010) argue that a good understanding of the impacts of climate change and its ramifications mobilizes political will to consider adaptation. In the five examined cities, local actors have understood the importance and the urgency of addressing climate issues, have voluntarily committed themselves, and decided to take climate measures that go beyond any legal obligation. This voluntary commitment is manifested and highlighted by the cities’ will to join the mayor’s adapt initiative, participate in environmental labels or competitions, and develop various local initiatives supporting the development and implementation of climate actions.

All five examined case studies have made environmental commitments at a local scale and have been working on climate mitigation and sustainable development for at least a decade. However, the timeline displayed in figure 54, putting the climate governance efforts of the examined mid-sized cities into perspective, shows that some engaged themselves earlier than others in environmental actions. Växjö for instance developed its environmental policy two decades before the city of Rouen set up its local agenda 21 which introduces the importance of sustainable development and calls for climate action. Nijmegen started with the construction of one of the biggest inland adaptation projects in 2011, the same year the city of Rouen set up its local agenda 21. Also, Växjö adopted its adaptation plan in 2013, the same year the cities of Leuven and of Rouen have developed climate plans that are rather focused on mitigation. This shows that there is a gap between the times in which these cities started taking actions. This could explain why some of the examined mid-sized cities are more prepared to deal with climate issues than others,

especially that in climate adaptation, responsible authorities learn from their trials to know which approach to adopt (Associate at the ICCCAD, interview, 2018).

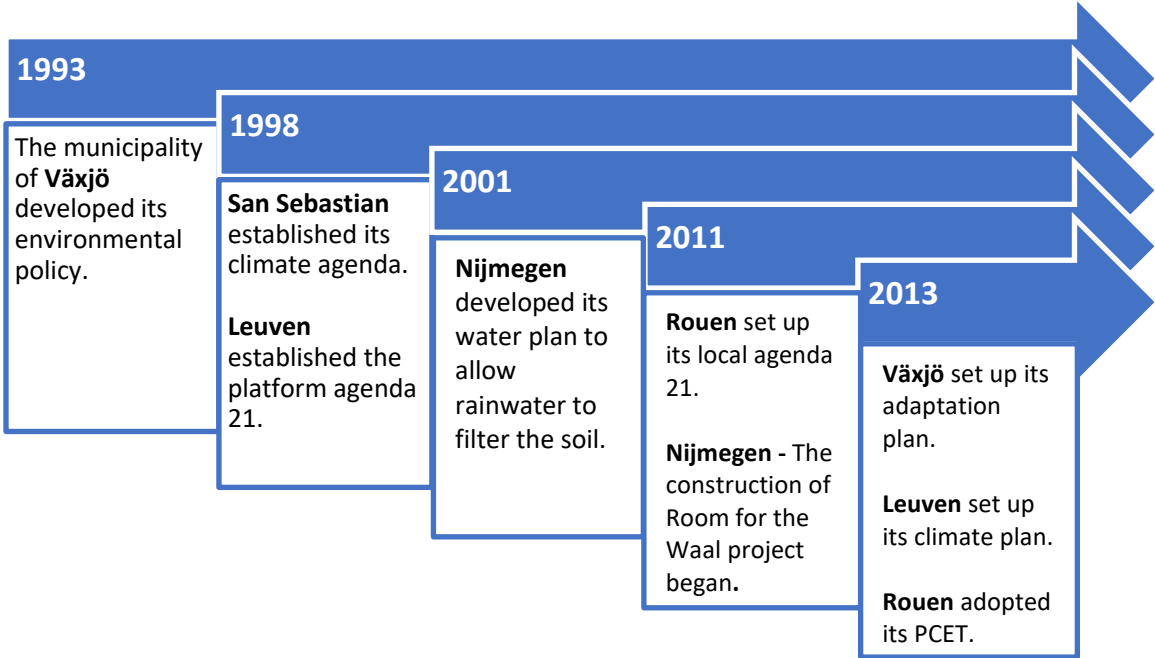


Figure 54 Comparative timeline of environmental and climate initiatives taken in each of the selected case studies.

The timeline above (figure 54) also shows that strategies, policies, and plans related to the reduction of emissions and the promotion of renewable energy seem to be more developed and elaborate than those related to adaptation. The development of adaptation policies is relatively more recent as it came to complement mitigation policies when the international community, the European Commission, and local governments understood that reducing emissions is not enough to tackle the issue of climate change (Environmentalist at the San Sebastian City Council, interview, February 2021). This finding exemplifies the research work of Füssel (2007), Hallegatte & Coffee-Marlot (2010), Aylett (2015), and Campos et al. (2016) among others which have asserted that adaptation has received far less attention than mitigation.

In all the examined mid-sized cities, there seems to be a political will to ensure greener cities and address environmental issues. However, the political stability could differ from one city to another impacting climate commitments. In the cases of Rouen, Leuven and San Sebastian, political changes could to a certain extent affect climate response. For instance, in the city of Rouen, the development of an adaptation plan was delayed due to political changes following the 2020 municipal elections (Municipality of Rouen employee in charge of ecological transition, interview, 2021). Whereas in Leuven, the 2018 municipal elections allowed the city to strengthen its climate and adaptation efforts as the green party came into the municipal coalition. In this context it seems important to underline that the city’s roadmap 2025 | 2035 | 2050 as well as the pressure from civil society and environmental NGOs played a role in assuring the continuity of climate commitments notwithstanding political changes at the heart of the municipality (Alderman in the board of mayor at the city of Leuven, interview, 2020). An environmentalist at the San Sebastian City council (interview, February 2021) affirmed that in the city there’s an overall stable political climate to

address climate issues, especially that the coastal city is facing imminent threats because of climate change, however, expressed that, changes in politics in the light of elections could affect the budget dedicated to addressing climate issues and its “position” on the priority list. In the cases of Nijmegen and Växjö, the political environment is considered an enabling and a success factor for climate governance as most political parties are in favor of sustainable development and consider addressing environmental issues as crucial (Van Standen & Musco, 2010; Cappelletti et al., 2015; Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). The results hence show the importance of developing a stable political climate as local elections may affect the city council’s effort, plans, and budget to address environmental actions. Political agreements could be drawn between various political parties getting them to establish common grounds in addressing environmental matters as presented in the case of Växjö. The city could also develop a long-term vision or a long-term strategy and assure the continuity of climate action as is the case in Leuven and San Sebastian. Not to mention, organizations and civil society play a great role in exerting pressure to assure that authorities are addressing environmental and climate issues.

The examined case studies have consulted with experts, urbanists, environmentalists, or environmental NGOs to guide the decision-making process. For instance, Metropole Rouen Normandy founded its ‘Local COP 21’ initiative in partnership with ADEME and WWF France. Similarly, the city of Växjö collaborated with one of the biggest environmental NGO in Sweden to develop an improved understanding of climate and environmental issues and address them. The Leuven 2030 organization collaborated with various actors including BUUR-an urban planning agency- to develop its roadmap to climate neutrality. The Province of Gelderland collaborated with the water authorities and municipalities (including the municipality of Nijmegen) to establish a Regional Adaptation Strategy (RAS). Similarly, the Basque government worked closely with the municipality of San Sebastian to develop the city’s climate adaptation plan. This underlines the importance of participatory decision-making in the development of environmental and climate strategies.

Various strategies, measures, and plans have been developed to adapt the examined territories to climate change. Most adaptation strategies and action plans are nonetheless developed at a regional level as is the case in Rouen, Leuven, and Nijmegen. The results have shown that the mid-sized cities which have developed local adaptation plans (i.e., the city of Växjö and the city of San Sebastian), have a more concrete approach to adapting the territory to climate events. Especially that- as underlined by the European Environment Agency report No12/2016 on urban adaptation to climate change in Europe- urban areas could present a unique set of circumstances affecting climate events.

In some of the examined cases, the municipality has a close working relationship with supra-municipal governance levels. For instance, the city of San Sebastian worked closely with the Basque country to develop its local adaptation plan in 2017. Moreover, Nijmegen did not feel the need to develop its own adaptation plan as it collaborated with the province of Gelderland and water authorities in the development of the regional adaptation strategy (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020).

However, in the cases of Rouen and Leuven, there is a lack of coordination and collaboration between the local municipality, on one hand, and the metropolitan area of Rouen and the Flemish

region, respectively, on the other hand. This lack of cooperation is due to differences in political between the local government and the supra-municipal one. It is remarked that, in these cases, climate efforts are duplicated as both levels of governance develop climate plans and ambitions in an uncoordinated way. This emphasizes the importance of aligning and coordinating local adaptation plans with strategies, plans, and measures that are developed by supra-municipal levels of governance to avoid having to re-invent the wheel. Mid-cities could thus use supra-municipal and regional adaptation strategies and plans as a starting point for developing a proper local adaptation response that is site and context specific.

The results have shown that in some mid-sized, adaptation policies are based on constitutional changes and new laws rather than an analytical review of the action or the development of new knowledge such as the case of Rouen. In this case, actors have developed a climate-air-energy plan without really understanding what are the problems that need to be addressed. This shows that legal obligations are not sufficient to provoke local actors to take appropriate actions. An understanding of the problem and finding the reason to intervene should be the basis for the development of climate action strategies and plans. Consequently, if a directive is to require the development of climate action and adaptation plans, it could mandate the development of a diagnosis determining impacts and vulnerabilities of the territory as a basis – as in the examined Dutch case where the Delta Plan on Spatial Adaptation established a deadline entailing all governments to identify climate vulnerabilities as well as opportunities.

In the examined cases, various environmental hazards have triggered the development of adaptation policies. For instance, in the Netherlands, the 1953 floods leading to nationwide damages and impacts triggered the development of water management policies and projects. In Nijmegen, the high river discharge incidents of 1993 and 1995 causing destructions in the city and leading to the displacement of 200 000 people have led to changes in policy and increased consideration to river floods. Additionally, the European heatwave of 2003 led to the development of the first Belgian “Ozone and heatwave plan” in 2005. Similarly, in France, each region had to realize a heatwave plan. In Leuven, the floods of 1891, 1980, and 1981 have led to policy changes as well as the development of measures related to flood protection. In Växjö, the eutrophication of the lakes in the 1960s and the oil crisis in the 1970s triggered the development of plans to restore water quality and reduce the reliance on fossil fuels. In San Sebastian, the heavy storm that hit the city in 2014 with strong waves causing damages to roads, buildings, and commercial shops have urged local actors to foster adaptation measures (Environmentalist at the San Sebastian City Council, interview, February 2021). This shows that governments are rather reactive and tend to develop adaptation measures following the occurrence of climate-related incidents when the threat feels more concrete and visible; and calls for developing simulations that permit to visualize the threat to act on it. In the examined case of San Sebastian, simulations were developed to improve the understanding of risks of the sea-level rise and were used as a basis for developing preventative measures. Comparably, in Nijmegen, simulations permitted to design the room for the river project to prevent flood risks. Charlès (2021), in a World Cities Summit webinar on Climate-Ready Cities & Sustainable Cities, emphasized the importance of developing simulations to evaluate risks and new urban development opportunities asserting that “this virtual reality could provide all decision makers a new visibility where dialogue could happen to transform the city and make it climate resilient”.

Baggioni & Bouisset (2018) and de Sartre *et al.* (2021) argued that authorities are likely to adopt climate action when they see immediate value for themselves and when there are co-benefits. Indeed, the results showed that even though the examined mid-sized cities were initially triggered to reactively address environmental and climate concerns following the occurrence of weather-related events, concerned authorities persisted in their commitments and strengthened their efforts as they saw direct and indirect benefits of addressing such issues.

The examined mid-sized cities have mostly introduced in their climate plans and adaptation strategies a series of small-scale initiatives such as increasing knowledge related to climate change, raising awareness, and increasing the share of green spaces and the permeability of the soil in urban areas.

Some of the examined cases have included adaptation policies in different environmental and policy plans. For instance, Nijmegen's adaptation is encompassed in the existent policy plans on greenery, water, and sewage systems. Similarly, for the city of Rouen, adaptation strategies are included in the city's PCAET. Both cities are planning on developing a proper adaptations plan but have not yet completed them. The city of Leuven developed a climate action plan (2020-2025) that includes an adaptation action plan. Also, the city of Växjö and the city of San Sebastian have developed proper adaptation plans in 2013 and 2017 respectively.

The cases that have developed proper adaptation action plans (i.e., Växjö and San Sebastian) seem to have more elaborate and precise adaptation policies. This underlines the importance of developing proper climate and adaptation plans that go beyond the mere development of a strategy, namely, specifying the measures to be taken, determining the person/the department in charge, the allocated budget as well as a deadline or a timeframe for the implementation of a given measure. On this basis, it is essential to underline the importance of keeping a good balance between being ambitious and pragmatic and the need to adopt realistic calendars, explore multiple transition paths, and envision various measures (Lulofs, n.d.; Vandevyvere, 2014). Given that mid-sized cities could find themselves with limited resources for the implementation of adaptation strategies, environmental action to be carried out could be organized in phases, divided into short-term actions, medium-term measures as well as long term actions, as it has been done in the case of the metropolitan area of Rouen, the city of Växjö and the city of San Sebastian. This allows determining the initiatives that address areas of priority and ensures the commitment of local authorities in the long run.

5.3 Implicating and Mobilizing Actors: Developing a participatory governance approach and joining networks to shed the light on local achievements

The literature review (section 2.3) presented the role of city networks and the role of awards and labels in fostering and supporting urban climate adaptation governance. The results showed that the examined mid-sized cities had various motivations to join city networks, to participate in national, European, or international environmental initiatives or programs, and to apply to environmental awards or labels. Joining such initiatives permitted local governments in mid-sized cities to offset some of the challenges faced in addressing environmental and climate issues. For instance, in 2013 the city of Rouen committed itself voluntarily to the Cit'ergie label to guide its local action and enroll in a process of continuous improvement and give a new dimension to its environmental commitment after it adopted its agenda 21 and its PCET. The label was also used

by Rouen to brand itself and stand out by improving the city's livability (Rouen Cit'ergie consultant, interview, 2019). The city of Växjö that have been addressing climate issues as of the early 1990s used the logo "the greenest city in Europe" in 2007 to promote itself as a green and livable city and worked on improving its environmental and climate strategy (Växjö commune, 2007; Saldert, 2015). Similarly, Leuven -committed to ensuring the city's climate neutrality by 2050- has worked on enhancing communication to shed the light on its efforts to promote itself as a model city in climate action (City of Leuven, 2020). In San Sebastian, the city council's technical team working in the environmental department is committed to leading the change and participating in innovative environmental and climate programs (San Sebastian Climate consultant 2, interview, 2020). The room for the Waal project -developed to protect the city from river floods- has put Nijmegen under the spotlight, attracted people from different parts of the world to see one of the biggest inland adaptation projects. Additionally, the city's application for the European Green Capital Award (EGC2018) created an opportunity to mobilize local actors and shed the light on the city's environmental efforts allows creating economic opportunities at a local scale. "These events have increased the municipality's motivation to sustain environmental and climate efforts" (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). The selected cases exemplify how mid-sized cities could use their environmental identity to promote themselves and attract investments and tourists (McCann, 2013; Emelianoff, 2013). The examined cities have found climate action as an opportunity to increase the city's attractiveness (to both residents and tourists) rather than a burden and are driven by the motivation to lead by example and brand themselves as green and livable cities. This underlines the advantages of addressing climate and environmental issues, and stresses the opportunities found in joining networks and committing to initiatives and labels.

The interviews showed that all five examined mid-sized cities are aware of the importance of developing a participatory governance approach and ensuring the involvement and representation of various stakeholders in the decision-making process and the implementation of policies and measures. Nonetheless, the degree of involvement of the public differs from one case to another. For instance, in San Sebastian, the municipality is working mostly on raising the awareness of citizens. Yet, to date, there is no formalized procedure to incite the participation of the public in the development and implementation of adaptation measures and more effort is needed on this front (San Sebastian Climate consultant 1, interview, 2021). Similarly, in the case of Rouen, participatory approaches are still at their embryonic stages, as the public is still a "spectator" or on the other side of the conversation in which it receives information but takes little part in the development and implementation of adaptation measures (Municipality of Rouen employee in charge of ecological transition, interview, 2019). Various initiatives were developed to incite public participation such as the "Je participe" crowdfunding project and the 'Accord de Rouen' initiative. Nonetheless, as acknowledged by the interviewed employee of the Regional environmental agency of Normandy (2019) more needs to be done to allow for informed citizens to play an active role in the development of local adaptation strategies.

In this context, it seems important to underline that public consultation processes could allow citizens to feel like they are effective members of society and increase the acceptability of proposed measures (Costa & Oliveira, 2015).

In the Belgian case study, the Leuven2030 organization played an important role in mobilizing actors of the territory. This non-profit organization represented all actors of society based on a

quadruple helix model, bringing together the local government, citizens, companies, and knowledge institutions. Similarly, in Nijmegen, a participatory culture is dominant; public meetings and roundtable discussions are organized to improve the comprehension of local circumstances and integrate the opinion of concerned and informed citizens in the decision-making process. In Sweden, there is a horizontal governance model, however, the results have shown that the city of Växjö could further improve its participatory governance approach by engaging the public sector and civil society in the decision-making process.

During the interviews, local actors from different municipalities have highlighted that the city can develop incentives to motivate citizens to take actions but cannot force the people to change their habits or make any decisions on their behalf (Environmentalist at the San Sebastian City Council, interview, February 2021; Environmental strategist at Växjö municipality, interview, 2020, Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Furthermore, environmental initiatives are likely to face opposition when people must change their way of doing things or when they must make compromises. For instance, when the municipality of Leuven proposed to transform a district into a car-free zone, there was some rising tension from people who believes that the city is not reachable anymore (Leuven municipal councilor representing the Green party, interview, 2020). A cultural and behavioral change is therefore seen as necessary to assure the success of adaptation governance efforts. To provoke this change, the Flemish government, and the city of Växjö suggested including environmental issues in the curriculum of schools to influence the behavior of the younger generation (Saldert, 2015). Also, the Flemish government proposed reforms to the curriculum in higher education and some technical courses to form students in different majors to consider sustainable development, energy, and water management as well as climate change in their practices (Flemish Government, 2015).

The examined cities are aware of the importance of engaging local businesses and workers in the economic sector. For this reason, the metropolitan area of Rouen is engaging local businesses through the “Rouen Climate Accord”. However, the latter does not include follow-up or penalty in case of non-compliance, companies could sign the accord to give themselves a ‘green image’ but not really respect these engagements (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). Likewise, in the examined Belgian case study, businesses and local companies are involved in the Leuven 2030 organization, however, an alderman in the board of mayor at the city of Leuven (interview, 2020) highlighted that being a member of the organization without an active engagement will not yield benefits. The city of Leuven is nonetheless collaborating with the local companies that are in the industrial zone on reducing the areas of hard surfaces and developing green areas. Similarly, the city of San Sebastian is working alongside a local cement factory, which is considered one of the biggest local companies with a large carbon footprint, on climate action (San Sebastian Climate consultant 1, interview, 2021). Some of the local companies in San Sebastian are also assuming climate based on their own motivation. That is mostly the case in Växjö, where the private sector companies are developing sustainable business practices to achieve competitiveness (Cappelletti et al., 2015). In the city of Nijmegen, water authorities are working closely with businesses and insurance companies in the process of adaptation. However, for many actors in the private sphere such as investors and workers in the construction field, climate adaptation is not necessarily on top of their minds (Climate adaptation strategist at the province of Gelderland, interview, 2020). Comparing these

cases shows that various efforts are developed by local governments to work closely with local businesses on addressing climate action. In some cases, businesses take their own initiative to do so. However, in the examined cities the efforts to engage the private sector is not particularly dedicated to climate adaptation and rather focused on offsetting GHG emissions. Additionally, there seems to be no follow-up to assess whether the engagement of local businesses is real or whether it is just a way to brand themselves and increase their competitiveness.

Adget et al. (2003 ; 2006), Füssel, (2007), Mees et al., (2012) and Ross et al. (2015) stressed the importance of multi-disciplinary discussion for developing a shared vision amongst actors from various sectors and levels and affirmed that adaptation should not be treated as a single isolated issue given that it affects various sectors as well as different levels of decision making. The examined case studies are progressively moving away from working in silos and assuring collaborations between various departments. However, the degree of coordination between different actors varies from one case to another. In Rouen for example, the sustainable development responsibility was attached to the general direction of the political service to ensure a transversal approach, however, climate adaptation is not necessarily mainstreamed across various sectors and many structures within the municipality still work in silos (Municipality of Rouen employee in charge of ecological transition, interview, 2019). In Nijmegen, the municipality organization embraced an integral approach in which many initiatives and projects are developed across all sectors (European Commission, 2017).

In the cases of Leuven, San Sebastian, and Växjö, a group was established with the responsibility to assure the coordination between various actors in different sectors. In Leuven, the 'Autonomous Municipal Urban Development' ensures project coordination, and the Leuven 2030 initiative has been a great catalyst to assure collaboration between various actors (City of Leuven, 2020). In San Sebastian, a technical commission for adaptation was established including members from various departments (San Sebastian Climate consultant 2, interview, 2021). Similarly, in Växjö, the interviews showed that a project group assembling different actors was established with an overall responsibility of developing a local adaptation plan, yet no actor carries the responsibility to monitor and coordinate the implementation of measures.

The results of this comparison present the importance of establishing a local group within the municipality, assuring the collaboration between various actors across different departments, through the development, implementation, and monitoring of local adaptation measures. This responds to some of the challenges to climate adaptation recognized by Clar et al. (2012) and Mees et al. (2012) including the institutional ambiguity with no clear or inadequate assignment of responsibilities to address climate issues.

Results have shown that it is also crucial to assure coordination and create vertical communication lines with supra-municipal levels of governance. The room for the Waal project is an example of an initiative that would not have been possible without the support of the regional and national government as well as the waterboard (EEA, 2014). Therefore, collaboration agreements could be drawn and established between the city and the governmental level that heads it. A regional network could be founded bringing together various municipalities to support their local efforts and guide their actions (e.g., the Udalsarea Basque network bringing together 200 municipalities to guide the action). An employee could be tasked to create synergies between the municipality

and the regional government, as is the case in Nijmegen which works closely with the Province of Gelderland.

5.4 Implementing Developed Strategies: Embracing opportunities, experimenting with small scale projects and the need to intensify efforts

In these examples, measures to protect the city from natural events and to increase its resilience were in place for decades even before developing an understanding of climate change and its impacts on the territory. For instance, measures have been in place to protect Leuven from the flood of the Dijle following the flood of 1891. These measures were reinforced following the floods of 1980 and 1981 (La Rivière, 2015). Interviews however showed that concerned authorities are aware that climate change will exacerbate the likelihood of such events and aims at reinforcing existing measures and developing new ones to adapt. Similarly, the city of Växjö has re-opened the Linnaeus canal to prevent the flooding of Lennagatan street and surrounding areas towards the end of the 1990s (EEA, 2016b). When the project was conceived climate change wasn't particularly a concern, however it assured the protection of the city from flooding events and presented an example of measures that could be implemented to adapt to anticipated climate risks. This shows that increasing resilience to natural events or other threats is not new and, for centuries, various measures were developed to protect cities and to increase their livability. However, with the boosted awareness that climate change will aggravate the risk of weather-related events, local authorities are intensifying existing measures assuring the adaptability of the territory or developing new ones. According to Kelin et al. (2007) Levin et al. (2012) and Chhetri et al. (2019) improving the resilience of a system in response to increasingly unfavorable conditions through the development of measures that are already in place, or the introduction of new ones is defined as 'incremental adaptation'. This demonstrates that the examined case studies have rather an incremental approach to adaptation that goes beyond the mere adoption of coping short-term passive-reactive approaches to maintain their essential functions in the face of experienced and projected disturbances. Berdoulay & Soubeyran (2014) and Filho et al. (2019), however, argued the need for surpassing incremental approaches to climate adaptation and presented the interest of transformative integrated adaptation approaches. Thereby, insisting on the importance of driving systemic changes to adapt to climate change. This underlines the need for new perspective when developing adaption approaches.

Successful urban projects in the examined case studies have embraced natural features within the city and saw water channels and rivers as an opportunity rather than a burden. For instance, Nijmegen has embraced the Waal River through the implementation of the room for the river project which aims at ensuring flood protection. Comparably, San Sebastian is seeing the Urumea river as an opportunity through the development of the submersible river park project 'Praque fluvial Txominenea' (Munguía, 2017). In Leuven, a lot of work is being done to give back the floodplain to the Dijle River (Leuven municipal councilor representing the Green party, interview, 2020). Also, the city of Växjö has seen the Linnategan canal as an opportunity to prevent floods (EEA, 2016b). Not to mention, the city of Rouen has embraced the Seine River through the rehabilitation of the riverbanks and the development of a green promenade allowing for citizens to reconnect with nature. This underlines the importance of building with nature rather than against it. De Vriend & Van Koningsveld (2012) and Slobbet et al. (2012) introduced building with

nature as an approach to adapting a system to climate change through recognizing connections between nature conservation, protection, and recreational functions.

A casual observation reveals that the selected cases have similar approaches to adapting to climate change, including the development of various small-scale initiatives, the combination of financial incentives, and the increase of the share of green and blue infrastructure systems. The implementation of small-scale projects seems to be attractive to local municipalities as it does not require a relatively large budget and allows for progressive improvement.

For instance, in Rouen, various pocket parks are developed. Also, the eco-district ZAC Luciline-Rives de Seine, covering the area of 9 hectares was conceived with climate concerns in mind (Moiroud-Musillo, 2014; City of Rouen, 2019). In Växjö, the city is working on increasing the permeability of the ground and developing retention ponds, green areas as well as integrated stormwater technologies. Nijmegen developed a similar approach working on the separation of rainwater from sewage and developing the “Operatie steenbreek” campaign which aims at replacing concrete and hard surfaces with pavement bricks to allow for the infiltration of water. Additionally, the city of Leuven is promoting bottom-up initiatives such as ‘Kom op voor je wijk’ project and is offering subsidies for the construction of rainwater installations and infiltration units. This demonstrates that the examined cities consider that developing the green and blue infrastructure increases the attractiveness and the livability of the city, increases the permeability of the ground and reduces the urban heat island effect. Local authorities should therefore work closely with urban planners and landscape designers to endorse sustainable urban developments and emphasize nature-based solutions based on an ‘Ecopolis Vision’, as the examined cases did (e.g., Bäckaslöv and the Västra Mark neighborhoods – Växjö, the northern neighborhood development – Nijmegen, etc.).

The examined cities are proof that investing in the development of blue-green infrastructure systems improves air quality, increases the permeability of the soil, and offers citizens a place for social interactions and leisure activities. This alleviates air-quality-related illnesses, it also limits flood risks, and reduces the exposure to the urban heat island effect. Creating synergies between environmental measures and other tasks at an urban scale is crucial. Drawing these links allows for financial benefits and increases the acceptability of the projects, offering thus various opportunities and accelerating the implementation of adaptation measures (Waterstraat, 2019). In this context, it is important to specify that when conceiving projects with a series of benefits, it is critical to consider and mitigate undesired co-impacts, or in other terms, adverse effects. For example, when increasing the share of green areas and creating urban parks, it is important to avoid a monotonous landscaping approach and plant a mix of different species to reduce vulnerability to drought (De Paep, Verachtert, & Van Reeth, 2019). It is also crucial to consider a careful selection of tree species and plant vegetation that is less allergenic and requires less watering, fertilizers, and pesticides, to reduce the risks of allergic reactions, increased water pressure, and soil pollution (De Paep, Verachtert, & Van Reeth, 2019). Consequently, decisions and policymaking need to be done in consultation with different experts and actors across various municipal departments and sectors. For instance, city planners could consult with experts in the field of agricultural sciences, as the city of Växjö did to ensure biodiversity and improves the soil’s capacity to retain water and store CO₂ when conceiving the development of the Bäckaslöv district.

One of the common challenges faced by the examined cities is the fact that the municipality can adapt public spaces and constructions owned by it to climate change, however, cannot directly intervene on plots that are privately owned. This was clearly underlined by a member of the Växjö climate commission (interview, 2020), by an alderman in the board of mayor in Leuven (interview, 2020), and in the case of Nijmegen where the expropriation of land was one of the challenging factors for the implementation of the room for the Waal project. This stresses the need to bring other actors on board. It is therefore important to assure a shared enthusiasm as well as the tangible engagement of various actors, which requires a good balance between top-down and bottom-up measures (Vandevyvere, 2014). The city could therefore incite and orchestrate change through the development of incentives, laws, awareness campaigns as well as the establishment of mechanisms facilitating the implementation of adaptation projects by property owners such as subsidies and technical assistance.

In the examined cases, many adaptation policies and projects are still in progress which makes it hard to assess whether the measures have increased the city's adaptability and resilience to climate events. Local actors have nonetheless agreed that more attention has been given by local authorities to adaptation in the past few years, yet more efforts and investments are required to ensure climate resilience cities.

Interviewees in Rouen and San Sebastian highlighted that the implementation of adaptation measures requires lengthy processes and results cannot be seen overnight. Officials of both cities are aware that there is still a long way to go, and successful experimental initiatives need to be replicated and scaled up (Municipality of Rouen employee at the directorate of attractiveness and living environment, interview, 2019; Environmentalist at the San Sebastian City Council, interview, February 2021). Comparably, the interviewed municipal councilor in Leuven (2020) acknowledged that the city has focused on the implementation of various small-scale adaptation initiatives, and now it needs to upscale its efforts. In Nijmegen, the city has been really invested in addressing water-related issues but needs to focus more on developing green infrastructure systems and measures to address the urban heat island effect (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Despite the implementation of various adaptation and storm measures in Växjö, heavy rainfalls in 2014 caused damages in the central part of the city, proofing that further adaptation efforts are required (Mayors Adapt, n.d.).

Some challenges and issues are common across the examined cases. The lack of financial, technical, or human resources seems to be impeding the implementation of adaptation projects and measures. This was expressed by various local actors. In some cities, this issue is more marked than in others. In the case of Växjö, the lack of various resources is not as marked as in the other examined cases, this could probably be justified by the decentralization of governance giving the city "the freedom" to manage its own resources and budget (especially that revenue tax is collected at a local scale). Not to mention, Sweden has a relatively stable economy. In contrast, in more centralized systems such as the case of Rouen, finding adequate resources for the implementation of adaptation measures seems more complex. However, while meeting with the alderman and environmental coordinators of the five examined cities, they have all stated that it is always a challenge to manage the environmental budget. The prioritization of actions is often necessary due to budget limitations. The situation underlines that there is a need to establish an appropriate climate financing mechanism. "Climate plans must estimate and express related

employment opportunities since this issue is vital for convincing politicians, citizens and companies to invest in the green economy” (Vandevyvere, 2014).

Local actors at the city of Rouen and San Sebastian highlighted that the lack of financial resources is inhibiting the city from hiring more people with expertise and is causing delays in the implementation of projects (Municipality of Rouen employee in charge of ecological transition, interview, 2019; San Sebastian Climate consultant 1, interview, 2021). In the cases of Leuven and Nijmegen, the collaboration with local universities have offset problems related to the lack of technical and human resources, however, these cities are actively seeking more funding to implement adaptation measures (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020; Alderman in the board of mayor at the city of Leuven, interview, 2020).

For the implementation of environmental and adaptation strategies, the city of San Sebastian is relying on funding from the Basque and the European government. Similarly, Nijmegen has received financial support from the regional and national governments. Several European, regional, and national funding schemes already exist. The problem with these schemes is that they're not easily accessible (ADEME et al., 2013). Therefore, it seems important to create a “one-stop-shop” and homogenize funding criteria to facilitate access to these aids.

The city of Rouen is aiming on stirring investments through developing a crowd-funding initiative. Accordingly, concerned citizens could propose an adaptation project benefiting the society and increasing the resilience of the territory to climate change and present it to the local community and local authorities. Once this project is approved by all parties, the city automatically covers part of the expenses of this project (E.g., 30 to 50 % of the cost), and the rest is covered by crowd-funds. This presents the opportunities that mid-sized cities could find to finance adaptation projects through establishing collaborations with supra-municipal collaborations and crowdfunding initiatives.

Results have shown also that cities, like Växjö, which are transparent in the management of their budgets and have a good reputation in the development and implementation of environmental projects have obtained funds from the national government and the EU for various projects more easily than others (Cappelletti et al., 2015). This stresses the importance of transparency in the governance of climate adaptation.

Attracting climate funds seem like a challenge as adaptation initiatives requiring large investments and the return on this investment is not seen as rewarding. However, a spatial adaptation report developed by the Dutch ministry of infrastructure and water management (2019) has shown that the cost of damage, if the city does not adapt to climate change and address the issue seriously, exceeds the cost of taking action. Concerned authorities could therefore calculate the cost of not adapting, based on projections, to improve their understanding of the budget needed for addressing environmental issues (Van Meeningen, 2016). It is nonetheless important to keep in mind that it is challenging to determine the value of climate impacts on human health and lives.

5.5. Monitoring and Evaluation: Assessing sustainable development and mitigation efforts rather than evaluating adaptation actions and measures

In the examined mid-sized cities, interviews showed that local actors know the importance of monitoring and assessing the development and the implementation of adaptation measures. Nonetheless, to date, there is no defined way to monitor and evaluate adaptation action at a local

scale. The systems that are used by local authorities to assure this follow-up, are rather general and are more focused on monitoring mitigation efforts, with indicators particular to monitor GHG emissions, the share of the produced and consumed renewable energy as well as the types of vehicles used for transportation. There are also some indicators to monitor sustainable development such as ones related to waste management and recycling or the production and consumption of sustainable goods.

For instance, the city of San Sebastian is experimenting with the SmartKalea initiative, a smart tool that collects and monitors data such as water and electricity consumption via smart meters (Formento de San Sebastian, n.d.). However, to date, this initiative is punctual and particular to 2 neighborhoods of the city and is rather focused on mitigation, not offering indicators that clearly identify the progress in the implementation of adaptation measures. Similarly, the city of Växjö has an “ecoBudget” tool allowing to manage energy, waste, nature conservation as well as water consumption with the same diligence as financial resources (Edwards, 2010) through determining an environmental budget and implementing measures and initiatives to reach the set target. Yet, this tool is not specific to assessing adaptation efforts.

To evaluate adaptation efforts, both the cities of San Sebastian and Växjö monitor the progress of the implementation adaptation measures and the degree of completion of planned actions, however, don't have measurable and quantitative indicators to assess local adaptation efforts (Environmentalist at the San Sebastian City Council, interview, February 2021; Member of the Växjö climate commission, interview, 2020).

The city of Nijmegen does not have indicators particular to monitor adaptation, especially that it hasn't developed an adaptation strategy yet (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). It relies on an annual city and neighborhood monitor which offers different indicators and looks at various programs within the city; some are relevant to assess sustainable development and others are rather general. Likewise, Leuven monitors various data at the scale of territory, including information relevant to environmental and energy management, and presents it in a yearly report “Leuven in numbers”.

The city and the metropolitan area of Rouen are using the Cit'ergie label to monitor their climate-air-energy actions. This tool offers metrics and indicators that allow the city to strengthen its strategy. Most of the indicators are related to sustainable development and mitigation but some can be used to monitor adaptation actions such as percentage of green areas, the average consumption of water in buildings, amount of water used for watering green spaces, the share of budget dedicated for awareness campaigns and the engagement of actors, the share of artificialized surface per year, among others. In addition to the indicators defined by the Cit'ergie label, the metropolitan area of Rouen has specified for each action in its PCAET, monitoring indicators. This allows monitoring each of the measures presented in the city's climate plan. Similarly, the city of Leuven has defined in its climate action plan a set of indicators for each of the proposed measures and actions (City of Leuven, 2020). These indicators include the number of green projects, the increase in the area of agroforestry and forests, the permeability of surfaces, overflow, and flood frequency, among others.

The examination of these mid-sized cities showcases that the monitoring and evaluation of adaptation strategies is a real challenge for local municipalities. Monitoring and evaluation systems are still at their embryotic stages and the development of specific indicators to measure and quantify the success of adaptation measures seems complex.

In all the examined cities there is however personnel, or a committee dedicated to assuring the monitoring and evaluation at a local scale. For instance, in the case of Rouen a Cit'ergie advisor is commissioned by the city or to evaluate the implementation of the PCAET. In Växjö, each administration has the responsibility to report to the municipality's environmental coordinator. In the cases of Leuven and San Sebastian, there is a climate adaptation committee responsible to monitor the progress of the adaptation policy plan and its integration across different city services.

5.6 Understanding Success and Limiting Factors: Lack of reporting to the public on the progress of adaptation measures and similitude in the challenges faced by local governments in mid-sized European cities

In the examined cities, some challenges, and success factors faced by local municipalities to adapt to climate change have been communicated in published reports. However, in general, conducting interviews with local key actors was essential to retrieve this information. This underlines that there is a deficiency in communicating and reporting back to citizens on the progress of environmental and adaptation measures through annual reports which is crucial to allow for transparency in the implementation of measures.

In the case of Rouen, the Cit'ergie label allowed identifying the areas of progress and the area requiring more attention. Comparably, the application for the European Green Capital award permitted the city of Nijmegen to understand the levers and limitations to climate governance (environmental researcher at the Radboud University, interview, 2020). This underlines the importance of committing to labels, awards, and environmental initiatives as these could present themselves as third-party assessors and a "fresh eye" determining success and limiting factors.

In San Sebastian, the new adaptation published in 2020 introduced the progress that has been made since the development of the first action plan in 2017 and defines the areas that need to be addressed (Gutiérrez et al., 2020). Similarly, Leuven's new climate action plan published in 2020 introduced an assessment of the previous action plan (2013-2019). The assessment did however not elaborate on the challenges and opportunities encountered by local actors (Environmentalist and researcher at the KU Leuven, interview, 2021). At a supra-municipal level, the Flemish government produced progress reports in 2015 and 2017 to reflect on the Flemish climate plan (2013-2020) and define success factors and gaps that need to be addressed.

The city of Växjö has produced reports on an annual basis since 2007 to monitor the objectives presented in the city's environmental program (Van Meeningen, 2016). These examples present the importance of developing an evaluation of adaptation initiatives as well as progress reports. In this context, it is important to underline that reporting on progress allows for an improved engagement of various actors and an increased trust of citizens in the governance system, which encourages people to work towards change and take their part of responsibility in climate action. Effective communication strategies could be designed to bridge the gap between personal concerns and climate change (Scannell & Gifford, 2011). The reporting could take the form of workshops, discussions rooms, and forums to discuss challenges and develop innovative solutions collectively. These exchanges do not have to be restricted to the actors of the territory; the city could promote a wider dialogue with actors in different cities of similar scale and with international experts and scientists.

Dynamics within the municipality and initiatives supporting the efforts of local authorities have been a key success factor as highlighted by various actors at the examined cities. For instance, the collaboration of the metropolitan area of Rouen with NGOs and environmental institutions, the as well as the establishment of local Cop21 initiative and a local IPCC have been crucial for developing and implementing environmental measures (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). Similarly, in Leuven, the organization 'Leuven 2030' has played an important role in supporting and accompanying the environmental efforts at a local scale (Alderman in the board of mayor at the city of Leuven, interview, 2020). In San Sebastian, the technical commission for climate adaptation is considered an important success factor as it allowed to create synergies and assure coordination among various actors (San Sebastian Climate consultant 2, interview, 2021). Comparably, the coordination of efforts and the engagement of various stakeholders have been crucial for the case of Nijmegen. That has been particularly underscored in the success of the room for the Waal project, which would have not been possible without the support of the province and the national government, the waterboards, and the local community (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Likewise, the internal coordination of efforts and the involvement of local stakeholders have been crucial for the city of Växjö. Adding to that, the collaboration of the city with the biggest environmental NGO in Sweden and the sharing of experiences and ideas with various cities in Sweden and the EU (Van Staden & Musco, 2010).

A commonly faced challenge has been evoked by local actors at the city of Leuven and the city of Nijmegen, which is despite participatory efforts, it remains a challenge to bring all the people on board, especially the ones with limited revenues. It seems to be easier to reach out to people with higher incomes, as sometimes taking climate actions requires personal investments (Alderman in the board of mayor at the city of Leuven, interview, 2020; environmental research at the Radboud University, interview, 2020). This stresses the importance of including the underprivileged population in climate discussions, fostering participatory approaches, and establishing different types of events and communications to reach out for all actors from various social and economic backgrounds. It also suggests the need for climate aid schemes for the population with limited revenues, especially that this population is often considered the most vulnerable to climate change (Expert on Climate change vulnerability and resilience in urban centers at the IIED, interview, 2018).

Adapting constructions in the old-town and the built heritage is also a challenge that is shared by the examined cities. This has been underlined by local actors in the city of Leuven, Rouen, San Sebastian, and Nijmegen. These European towns have a rich history and have densely built centers making it more challenging to adapt the built infrastructure to climate change. It is easier to adapt new constructions, such as the case of Nijmegen who saw the expansion of the city north of the river as an opportunity to build a new district based on the Ecopolis approach (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). This calls for developing research on ways to adapt historic centers to climate change while conserving the cultural and architectural heritage.

The investment in research and the development of new studies allows to close knowledge gaps and address the challenges faced by local authorities; especially that adaptation is still a relatively

new area of focus in many of the examined mid-sized cities and adaptation measures are still at an experimental level.

Cities are dynamic 'built laboratories', therefore, it is fundamental to understand the variables and factors affecting urban resilience. Key local actors could test adaptation measures and learn from their trials to know which actions to implement (Associate at the ICCCAD, interview, 2018).

5.7 Improving the Governance System in Place: Projections, long-term visions, and contingency plans

In the five examined case studies, climate projections have been developed to improve the understanding of the impacts of climate change on long-term horizons. The projections have considered various scenarios, ranging from low to high impact, based on global climate mitigation action, and give a general overview of the evolution of local climate conditions. Results have shown that climate projections presenting changes in climate conditions on the horizons 2030, 2050, and 2100 do not eliminate ambiguity. Not to mention the high uncertainty makes it challenging to model or determine local climate disturbances (ADEME et al., 2013) and develop accurate response as climate adaptation is scale- and context-specific and is characterized by both short- and long-term time frames (Adger et al., 2003; Scannell & Gifford, 2011; Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). The local actors of the examined cities have nonetheless understood and underlined that despite uncertainties and related challenges, it is necessary to act and adapt the territory to climate change.

Results showed that the examined mid-sized cities, particularly Växjö, Leuven and Nijmegen are witnessing a remarkable population growth and that this trend is increasing which presents both opportunities and challenges in terms of sustainable urban development. The cities of Nijmegen and Växjö have developed new neighborhoods based on an ecopolis vision to accommodate the population growth. This stresses the importance of taking demographic changes and factors into consideration in addition to climate projections when planning for resilient cities.

Apap (2019) presented the concept of 'climate refugee', as extreme climate events in developing countries are likely to result in mass migration flows into Europe, and member states are expected to be dealing with demographic changes and with the flow of environmental refugees (Apap, 2019). It has however been remarked that none of the examined cities evoked this concept or included it in its environmental or sustainable development strategy. This calls for having a broader vision when considering the impacts of climate change as some could indirectly impact the cities such as the flow of environmental refugees evoked by Apap (2019).

Literature review presented adaptation as an ongoing process. It affirmed that the knowledge and the experience acquired due to experimentation in the implementation of adaptation measures brings new insights that should be considered and used as a basis for the update of existing measures or the development of new adaptation plans following an adaptive management approach (Rijke et al., 2012; Marmorek et al., 2019). "Possibilities to adjust a transition path while proceeding on it are necessary because contextual parameters change continuously" (Vandevyvere, 2014). Making these amendments for continuous improvements is necessary because if no success is noticed, local actors could lose motivation to address the issue (Vandevyvere, 2014).

As adaptation requires long-term timeframes, action plans are being reviewed and measures are being adjusted based on new insights and knowledge in most of the examined cases. Yet, the development of a new adaptation plan was based on legal requirements and structural changes in the case of Rouen, where new laws led to the development of the metropolis of Rouen Normandie and required the development of a PCAET.

The development of new knowledge, the update of existing adaptation strategies, and the development of new measures in alignment with the city's long-term vision have allowed for the flexibility of long-term adaptation approaches in each of Växjö, Nijmegen, San Sebastian, and Leuven. In contrast, in the case of Rouen, the interviews underlined that short-termism and the lack of a long-term vision have limited the ability of authorities to ensure the flexibility of adaptation policies and projects. Haasnoot et al. (2013) and Magnan et al. (2020) asserted that the 'adaptation pathway' approach considering a 'what if' scenario allows for flexible decision making and allows to address the challenges presented due to uncertainty.

The cities of San Sebastian and Nijmegen have developed a "roadmap 2050" and a "climate-proof 2050" ambition, respectively. This enhances the continuity of climate adaptation actions and the long-term perspective of sustainable development actions and measures that are taken at a city scale (Environmentalist at the San Sebastian City Council, interview, February 2021; Adaptation policy advisor at the municipality of Nijmegen, interview, 2021). Likewise, the city of Växjö, developed its sustainability agenda 2030 as part of a broader "vision 2050" and tasked the evaluation responsibility to the sustainability committee at the municipal council (Växjö commune, 2019). Comparably, the city of Leuven developed a 2025 | 2035 | 2050 roadmap defining a guideline for the city's vision to become climate neutral by 2050. A team of program facilitators was established to translate Leuven's vision into concrete actions. The long-term vision seems to allow the flexibility of the measures as actions are re-adjusted along the way to assure an alignment with the long-term vision, but "what is more important than defining long term goals, is assuring the follow-up and the implementation of concrete actions that align with this vision" (Environmentalist and researcher at the KU Leuven, interview, 2021). This issue is particularly faced in the case of Rouen where some newly developed public projects do not align with the city's sustainability plan. Concretely, Rouen has stated its intention to greening the city, however, many projects and buildings are constructed in a traditional way with no regard or consideration to reducing the area of mineralized surfaces (Regional environmental agency of Normandy employee, interview, 2019). That comes in a context in which Rouen has not really developed a long-term vision, especially when it comes to adaptation. The city's long-term commitments are broadly introduced in the local Cop21 initiative and are focused on reducing emissions and increasing the share of renewable energy by 2050 (Métropole Rouen Normandie employee at the directorate of environment and energy, interview, 2019). Thereby, the development of a long-term vision in the form of a drafted long-term strategy, a roadmap (e.g., the case in Leuven), or a slogan (e.g., "the greenest city in Europe" used to brand the city of Växjö and underline its long-term commitment), could offset short-termism and assure the flexibility of approaches.

De Nazelle et al. (2011) asserted that changes in the way cities are designed and built are crucial to develop healthier cities through promoting active travel and mitigating climate change. The findings of this thesis showed that, in addition to that, developing a new mindset that considers

climate change as well as the increased stress on the environment when designing and implementing new urban projects could permit to increase the resilience of cities to climate change. Not to mention, new projects present an opportunity to make positive changes and implement measures that align with the city's long-term vision instead of building in the same traditional manner with no consideration to climate change. As a case in point, the 'Nijmegen North' neighborhood developed to accommodate the city's population growth providing 12,000 houses, is built in a sustainable matter based on an 'Ecopolis approach' increasing the city's resilience to climate change (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Similarly, the development of the new city district of Bäckaslöv was conceived with a focus on people in the design in contrast with the traditional thinking which considers that, in a city, cars dominate the space and sidewalks are provided for people (AFRY, n.d.). The new district prioritized pedestrians and green areas in the streetscape. Also, the district's park was designed to include a sunken playground acting as a water retention basin to prevent floods in times of cloudbursts (AFRY, n.d.). These projects present examples of projects ensuring co-benefits through increasing the livability of the neighborhoods, mitigating, and adapting to climate change. They also underline the range of opportunities that new urban projects offer and stress the importance of creative thinking and forward planning when dealing with emerging hazards.

Developing emergency responses is seen as crucial for climate adaptation which is defined by Füssel (2007) as the process of building resilience, recovering, and profiting from any opportunity that could arise due to changes, shocks, or stresses.

In all the examined mid-sized cities, emergency plans are in place to overcome risks or unexpected events. For instance, in Växjö, the Värends rescue service is conscious that Kronoberg county is exposed to various environmental threats such as storms, floods, fires, and power outages and has developed respective protection measures in collaboration with municipality members for crisis, fire, and risk management issues (Värends Räddningstjänst, 2018). Likewise, San Sebastian has a flood emergency plan as well as a municipal plan against forest fires and has emphasized in its adaptation the importance of periodically updating the existing protocol of the services of flood emergency considering the effects of climate change. Additionally, a mobile application (DSS Klima Adapt) was developed allowing the improvement of access to information and a better response in cases of emergency. In Rouen, a municipal protection plan was developed to increase the preparedness for various events of emergency including natural risks, health risks, technological risks as well as extreme weather events (City of Rouen, 2013).

The city of Nijmegen, with the support for the VRGZ (an organization for the preparation and coordination in the field of crisis and disaster management), is prepared to deal with unexpected weather-related events as disaster response plans are drawn up addressing floods, long-term outages of utilities among others (VRGZ, n.d.). However, it has been highlighted by the interviewees that Nijmegen is more prepared to address floods risks than to deal with heatwaves as the latter is not yet considered a threat that is included in security plans (Adaptation policy advisor at the municipality of Nijmegen, interview, 2020). Comparably, an alderman in the board of mayor at the city of Leuven (interview, 2020) underlined that climate events are not yet perceived as imminent risks in Leuven consequently no contingency plans have been developed locally to address unexpected extreme climate events. Nonetheless, in Belgium a national platform has been developed for disaster risk reduction and emergency action plans have been established

by the state for flood and forest fires. Additionally, as soon as a disaster occurs, the general system of emergency planning is triggered at different levels of governance.

Broadly, the examined case studies have developed the capacity to respond rapidly following the occurrence of unavoidable climate-related events through the development of contingency plans, alert systems, and the mobilization of emergency services. Climate events such as heavy storms, floods, forest fires seem to be already considered by local municipalities as viable threats that need to be included in local, regional, or national security plans. The issue of heatwaves is nonetheless still not considered a major threat and notions of this impact are still “timid” in disaster response plans.

5.8 Assessing the Urban Climate Adaptation Governance: Benchmarking efforts

Using the developed index allowed to compare these cities to one another especially that the same indicators are used as a basis to assess the efforts of local governments to adapt to climate change. Based on the presented results and the computed adaptation governance index scores for each of the examined cities, Växjö scored the highest with 9.0/10. Nijmegen followed as the second with an urban adaptation governance value of 8.6/10. San Sebastian came 3rd, with an urban adaptation governance score of 8.4/10; Leuven stood 4th with an urban climate adaptation index equal to 7.8/10 and Rouen came last with an adaptation governance index with a value of 5.8/10 (*Section 3.6.2 further explains what the numerical values of the index mean in terms of climate adaptation governance*). In this context it is nevertheless important to underline that the value computed in each of the cases is not absolute. The value presents a proposed assessment to evaluate adaptation governance efforts based on defined indicators and a schematic method and permits to juxtapose the efforts of local authorities in different mid-sized cities.

The Index scores are presented in the diagram below (*figure 55*) allowing to benchmark the adaptation governance efforts of selected cities. The “urban adaptation” column presents an “ideal” situation with a full urban adaptation governance score.

The diagram introducing a comparison of the urban climate adaptation governance indices of the selected case studies figuring below (*figure 55*) shows that San Sebastian, Växjö, and Nijmegen are leading in the area of understanding impacts. The city of San Sebastian is leading in developing adaptation strategies. The cities of Växjö, Leuven and Nijmegen have also a relatively good performance in this area. Efforts to implicate and mobilize actors are prevalent in the case of Leuven, where ‘Leuven 2030’ an environmental organization is established bringing together around 500 members to stimulate climate-neutral and sustainable development projects and initiatives in the city. The city of Växjö is leading in implementing developed strategies and improving the governance system in place. Monitoring and evaluation efforts are more developed in the cases of Rouen and Nijmegen. There is no major difference between the examined cases in the area of understanding success and limiting factors. The city of Rouen however needs to put more effort as, in comparison to the other selected cities, it seems to be lagging in different areas of governance, except for the area of monitoring and evaluation.

The graphical representation (*figure 55*) below shows us concretely how the developed index not only allows to assess climate adaptation governance efforts of a particular city and define areas

that require more focus, but also allows to compare the adaptation governance efforts of various cities.

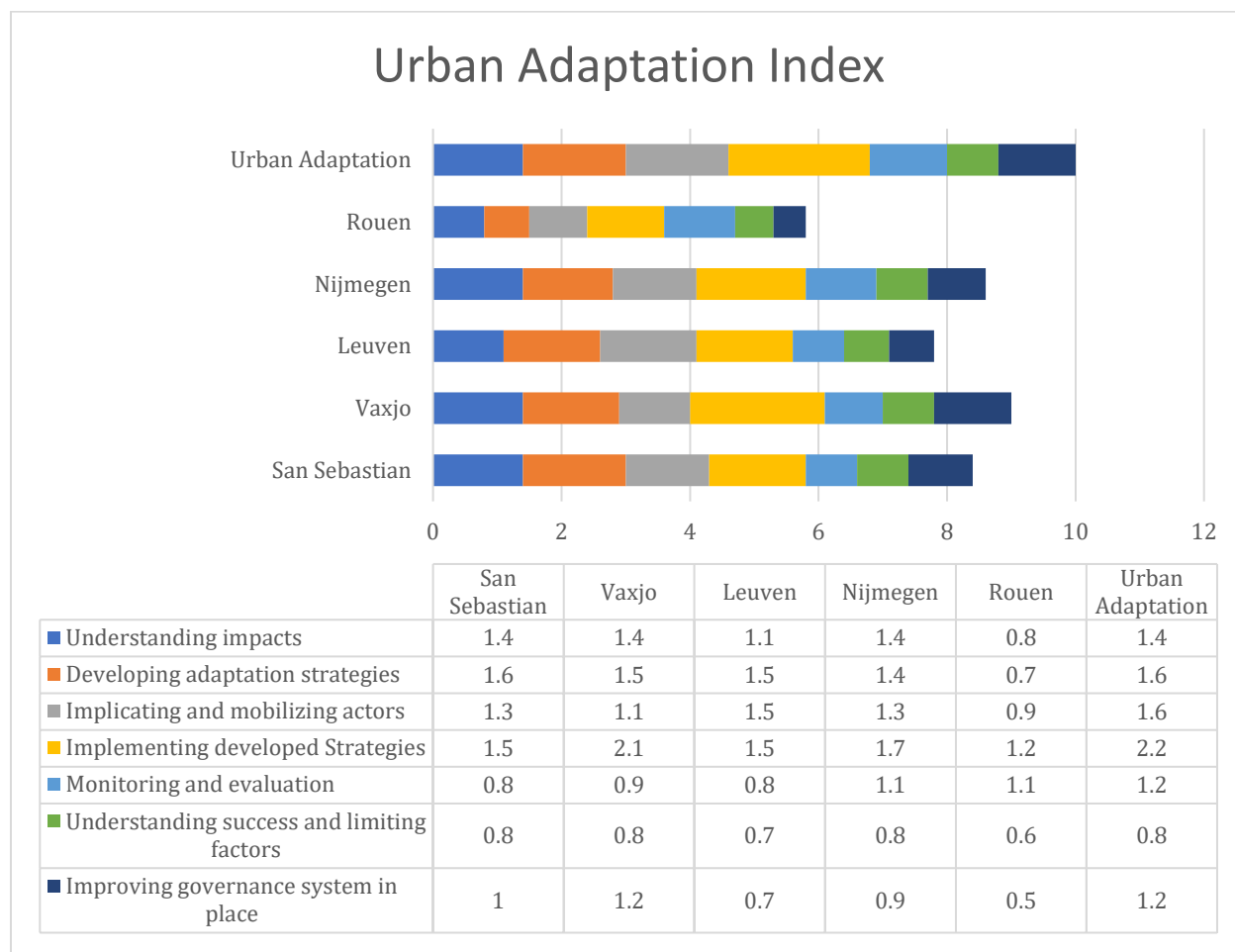


Figure 55 Comparison of climate adaptation governance indices of the selected case studies.

Among the selected cases, Växjö and Nijmegen proved to be leading climate change adaptation through developing favorable governance approaches. These cities have several things in common. First, they have developed an understanding of impacts, they have integrated adaptation measures in the development of their cities for over a decade and have embraced a participatory governance approach. These cities have a stable political climate and elected councils have high awareness and the willingness to address environmental and climate issues. Not to mention, these cities have a great deal of competencies and responsibilities due to a decentralized governance structure allowing local authorities to develop and implement site-specific tailor-made environmental and adaptation measures in response to experienced impacts. Adaptation governance approaches are also favorable in the city of Leuven and San Sebastian. Remarkably, both cities have developed a long-term vision and are working to ensure synergies among various actors within the municipality. Among the selected cities, Rouen has the lowest value for the adaptation governance index. This could be explained by the fact that the city has to improve its understanding of the impacts of climate change at a local scale. This city lacks a long-term vision and has a weak collaboration with supra-municipal levels of governance, additionally, various municipal actors work in silos.

CHAPTER 6: DISCUSSION AND CONCLUSION

6.1 Discussion

To test the designed methodology, it was first applied to the case of Rouen. Data collected through the review of documents and interviews were used to answer the set of 50 close-ended questions forming the urban climate adaptation governance index. To assure that the assessment of adaptation governance efforts is valid, at a first stage, the compiled data determining adaptation efforts of the city of Rouen were handed to master's students in environmental technology at Imperial College London who were asked to answer each of the questions addressed in the developed index. The comparison of the answers of the author to the answers of the masters' students showed no significant difference, however, it revealed that some questions needed to be rectified to be more precise (*refer to appendix IV - table 17 & 18*). Not to mention, throughout the course of the development of the research project, and based on collected data, some questions had been redefined, allowing for a more accurate assessment of adaptation governance efforts.

Once the methodology was tested for the city of Rouen and proved to function -allowing to evaluate adaptation governance efforts of the city- it was applied for the cases of Nijmegen, Leuven, Växjö, and San Sebastian. Consequently, relevant climate and adaptation governance data were collected for each of these cities and used as a basis to evaluate their climate adaptation governance efforts using the proposed index embracing 50 assessment questions.

At a later stage, key local stakeholders at the examined cities were asked to use the urban climate adaptation governance index as a self-assessment tool. The purpose of this exercise is twofold. First, it cross-checks and validates the data collected by the researcher and assures an adequate assessment of governance efforts. Second, it tests whether this index could be used by local authorities themselves as an auto-evaluation tool allowing them to evaluate their adaptive capacity due to adaptation governance efforts, and to define areas of adaptation governance that need to be further invested in.

City	Interviewees who collaborated to test the urban climate adaptation governance index as a self-assessment tool	Number of questions answered/ Total number of questions forming the urban climate adaptation governance index
Rouen	Climate researcher at the University of Rouen	47/50
	Municipality of Rouen employee in charge of ecological transition	50/50
Nijmegen	Environmental researcher at the Radboud University	46/50
Leuven	Leuven municipal councilor representing the Green party	50/50
Växjö	Member of the local climate commission	50/50
	Sustainability municipal administrator	47/50
San Sebastian	Associate at the Public Society for Environmental Management of the Basque Government (Ihobe)	46/50
	Environmentalist at the city council	50/50

Table 4 List of interviewees who collaborated to test the urban climate adaptation governance index as a self-assessment tool, and the number of questions answered out of total questions forming the developed index.

Interviewees who were initially contacted for primary data collection were recontacted to test this urban climate adaptation governance index as a self-assessment tool. In Rouen, only two responded positively and agreed to collaborate: a climate researcher at the University of Rouen and a municipality of Rouen employee in charge of ecological transition. In Nijmegen, an environmental researcher at the Radboud University was the only one who responded to solicitations. In Leuven, two of the contacts who were initially interviewed showed interest in testing the self-assessment tool. Eventually, only a Leuven municipal councilor representing the Green party committed to doing the auto-evaluation exercise. In Växjö, a member of the local climate commission as well as a sustainability municipal administrator collaborated to test the designed index as a self-assessment tool to evaluation adaptation governance efforts allowing to increase the city's adaptive capacity in the light of climate events. Lastly, in San Sebastian, two responded positively and agreed to participate: an associate at the Public Society for Environmental Management of the Basque Government (Ihobe) and an environmentalist at the San Sebastian city council.

Out of the interviewed people, municipality employees working on climate issues and members of the local climate commission seemed to be able to answer all the questions forming the urban climate adaptation governance index. Meanwhile, employees working at other departments, university researchers and actors at regional levels were able to answer most of the questions forming the index. The interviewed actors who did not have answers to the addressed questions asserted that concerned experts working on climate issues at the heart of the municipality would be able to provide this information. This shows that this tool could be used by the local government itself to assess the city's progress in terms of the governance of adaptation at a local scale. A third party may not have answers to all the questions forming the urban climate adaptation governance index. Employing this assessment method necessitate some data that responsible authorities possess, thus collaboration with the city council or experts who are working closely with it on climate issue is necessary to retrieve the needed data.

The results of the comparison between the author's answers to the questions forming the urban climate adaptation governance index and the answers of a climate researcher at the university of Rouen (*refer to appendix IV – table 19*) showed no significant difference. Nevertheless, the researcher at the university of Rouen (interview, 2021) considered that there are efforts to develop local vulnerability assessments particular to medium sized cities (50,000-250,000), meanwhile the research work showed that most efforts are conducted at a regional scale (especially when comparing Rouen to other cities such as San Sebastian and Nijmegen that have developed vulnerability maps at a local scale). The climate researcher at the university of Rouen (interview, 2021) considered that there is no adaptation strategy while the author found that adaptation approaches are included in the PCAET developed by the metropolitan of Rouen and the climate action plan of the city of Rouen. The author considered -based on collected primary and secondary data- that there is no clear identification of levers and opportunities as adaptation measures are still at an experimental level, meanwhile the interviewed climate researcher at the university of Rouen estimated that local actors are aware of the opportunities to climate adaptation. According to the author's assessment, adaptation policies have been developed based on new laws and constitutional changes rather than an improved understanding of vulnerabilities and impacts,

meanwhile, the climate researcher believed that throughout the years increased knowledge allowed local actors to rectify their adaptation approaches. Lastly, the author considered that emergency plans are developed to overcome environmental events, meanwhile the interviewed climate researcher asserted that in Rouen, environmental threats are not yet fully integrated in emergency plans (Climate researcher at the university of Rouen, interview, 2021). The results of the comparison underline that a factor of relativity could come into play when assessing adaptation governance efforts. Even when having close-ended questions, assessors having different views could have different answers impacting the assessment. Additionally, some assessors may be more lenient than others when evaluating adaptation governance efforts.

Comparing the author's answers to the answers of an environmental researcher at the Radboud university showed no significant difference. Yet, the author (based on collected data) considered that there is no adaptation strategy developed at the scale of Nijmegen instead adaptation actions are mainstreamed across policy documents, while the researcher at the university of Radboud (2021) saw that the regional adaptation strategy could act as a local one given that Gelderland is a small province. The author considered that there is no clear assignment of tasks and responsibility, meanwhile the environmental researcher at the Radboud University (interview, 2021) affirmed that "on paper there is, but in reality, no". The author considered that there is room for improvement for the implementation of green adaptation measures as the city is rather focused on flood management, meanwhile the interviewed researcher believed that the city is implementing green adaptation measures. Lastly, the author considered that emergency plans allow to overcome environmental events, meanwhile the interviewed environment researcher asserted that in Nijmegen, flood threats are included in emergency plans, yet underlined that there is room for improvement for heat stresses (Environmental researcher at the Radboud University, interview, 2021). This stresses that some of the addressed questions forming the index could be constituted of sub-questions to permit for a more accurate adaptation governance assessment as some cities could have a higher adaptive capacity to food risks and be less resilient to UHI effects.

Contrasting the author's answers to the questions forming the urban climate adaptation governance index to those of a Leuven municipal councilor representing the Green party shows that the latter had a more optimistic view on the city's efforts to adapt to climate change. Meanwhile, the interviews with various parties (i.e., an associate at the Flemish environment agency, a researcher at the catholic university of Leuven, an alderman in the board of mayor, and a Leuven municipal councilor representing the Green party) to gather data complementing the review of documents and reports, in adaptation assessment, underlined that there is some room of improvement in various governance areas. This stresses the importance of dialogue and the necessity of considering the various point of view when evaluating the city's efforts to adapt to climate change. Conducting this assessment from a single perspective, not taking into consideration the information, evidence, or insights that different actors could have, may affect the objectivity of the results.

The case of Växjö showed, that a member of the local climate commission was able to answer all the questions forming the adaptation governance index, meanwhile 47 out of the 50 questions were answered by a sustainability municipal administrator. The latter did not have answers to whether the monitoring and evaluation is continuous and periodic and to whether there were

personnel, or a committee dedicated to ensuring the monitoring and assessment at a local scale. He also couldn't tell whether monitoring and evaluation results are reported and communicated with targeted groups to inform practice and policy. This underlines that not all personnel at the heart of the municipality are familiar with all areas of climate governance including the development of strategies, the implication of actors, the implementation of measures and the steps that succeed implementation.

The comparison of the author's answers to the questions forming the urban climate adaptation governance index to the answers of an environmentalist at the San Sebastian city council and those of an Associate at the Public Society for Environmental Management of the Basque Government - Ihobe, showed that there is some gap between the answers of the municipal actor and the regional actor (*refer to appendix IV-table 23*). For instance, the regional actor considered that financial and human resources are made available for the implementation of strategies given that the Basque government offer the city of San Sebastian funds to support its adaptation efforts, while the municipal actor considered that this fund is not enough and that the city has to seek other funding opportunities (Environmentalist at the San Sebastian City Council, interview, June 2021). Also, the regional actor considered that a monitoring and evaluation system is embracing quantitative and qualitative indicators, whereas the city of San Sebastian actor considered that the monitoring and evaluation system in place is weak embracing solely qualitative indicators permitting to evaluate the progress of adaptation measures. This underlines the necessity of vertical communication lines as actors see the matter from different perspectives. It also stresses the role of local authorities in improving urban resilience and determining progress in adaptation efforts as they demonstrated to be the actors that are the most familiar with their territory and its specificity.

The application of the conceived urban adaptation governance index proved that it permits interested parties to evaluate the adaptation efforts of a mid-sized city. However, to be able to have a correct assessment, it seems imperative to develop a good understanding of the situation with the input of different actors that could have various perspectives on the situation. Some data necessary for the evaluation of adaptation governance effort is in possession of local actors, thus the importance of assuring a collaboration with the concerned alderman or environmental coordinators of a given city. The testing of the tool showed that it has a relatively high accuracy level, given that different users or assessors had more or less the same answers or results. The tool could however be further improved through including sub-indicators that leave no room for ambiguity. The accuracy of the tool could also be improved by developing a more complex scoring system. However, simplifying the scoring system was in this case intentional, as this thesis does not aim on providing an absolute value for adaptation governance efforts as much as it aims to provide a simplistic tool that can be used to juxtapose governance efforts and permit local governments in mid-sized cities to understand the strength and the weaknesses of their adaptation governance approach.

The testing of the methodology through a feedback loop demonstrated that, indeed, it could be used by local governments in mid-sized cities to assess their urban climate adaptation action, permitting to identify the areas of adaptation governance that need to be further improved to boost a mid-sized city's resilience to climate events. However, it should be noted that while the index assesses the governance of adaptation and assumes that good governance can contribute to greater urban resilience, it does not directly assess the relevance and effectiveness of the

adaptation measures and solutions themselves or whether those chosen by the studied cities are the most appropriate and effective.

Given the nature of this contemporary and evolving research problem, data collection was a challenge. The fact that climate adaptation is relatively a recent area of study, and that the existing literature is rather focused on big cities, this research necessitated the review of grey literature (e.g., adaptation strategies and plans, guides, reports, factsheets, audiovisual media, e-prints, etc.). It was crucial to validate the accuracy of the information communicated in these reports. Consequently, it was necessary to conduct interviews with key local stakeholders to draw a better understanding of the actual situation in terms of adaptation governance in each of the investigated cities. The availability of interviewees and their knowledge of the topic was thus critical for the development of this thesis.

The research also examines five mid-sized European cities, which represents a relatively small sample size in comparison to the total number of cities of this scale located in the European continent.

Another limitation to this research is not being able to organize field work -necessary to develop a clearer understanding of the situation on the ground- for all case studies due to covid 19 travel restrictions.

The fact that cities present dynamic environments in which things evolve rapidly, and that the city's response and resilience to climate events is not a static characteristic made this research particularly challenging. Thus, political changes, updates to environmental policies, environmental and weather-related events, as well as the responses of local governments to climate adversities had to be considered throughout the development of this research work as variable factors affect the computed urban climate adaptation governance index. The data collection for each of the selected cases had to be reworked at the end of the research to ensure that it includes the most up-to-date information. With every newly acquired information, the score of the index was susceptible to change. For instance, at a first glance and based on reviewed grey literature, the city of Rouen seemed to be implicating and mobilizing actors and ensuring the implementation of adaptation measures to increase the resilience of its territory. However, after interviews were conducted and following the field visit, the city seemed to be lagging in these areas. Interviewees clarified that citizens are on the other side of the conversation and that there is no real participatory governance. Additionally, the site visit clarified that adaptation initiatives were rather punctual (e.g., Eco-quartier ZAC Luciline) and not scaled up to ensure the adaptive capacity of the entire city in the face of climate events. This shows that there is a chasm between data that is communicated to the public and reality and stresses the need to have a clear understanding of the whole picture to be able to measure adaptation governance efforts.

Furthermore, based on primary and secondary data collection, the city of Rouen seemed to have an identification and mapping of vulnerable areas to climate impacts as the Flood Risk Prevention Plan identifies the part of the city that are vulnerable to floods. However, when reviewing other cases such as the case of San Sebastian and the case of Nijmegen, that have developed maps at the scale of the city identifying the areas that are exposed to the UHI effect and floods as well as a mapping of green and permeable surfaces, the identification of vulnerable areas in Rouen seemed to be relatively weak. This stresses the 'relativity' aspect in the assessment of adaptation

governance efforts to increase the city's resilience to climate events. This aligns with Rutter (2006)'s definition of resilience as "a relative resistance to environmental risk experience".

6.2 Conclusion

This research project aimed to determine whether governance efforts of local authorities in mid-sized European cities are contributing to increasing the adaptive capacity of the territory and its resilience to climate events.

Consequently, questions were raised to develop a further understanding of the current efforts in place to govern climate adaptation in a range of cities, that is, based on the selection criteria, considered as frontrunners in this field. These efforts include an understanding of the impacts, the mobilization of actors, the development, implementation, and follow-up of adaptation strategies, the identification of levers and challenges as well as the continuous improvement of the governance system in place. To assess if the adopted governance approach to adapt to climate change, in each of the selected case studies, is adequate and ensuring a resilient city, an index was developed to assess urban climate adaptation governance based on 50 indicators.

This methodology allowed to benchmark adaptation efforts of different cities and to define the areas of governance to which the city needs to dedicate more effort. The tool could also be used by local authorities as a guideline for climate adaptation.

The findings of the research and the comparative study offer no ground for generalization as the selected case studies only present a small sample and do not necessarily depict the situation of all mid-sized European cities. However, these findings draw a general picture and allow for an improved understanding of challenges and opportunities of climate governance found in cities of a similar scale.

In conclusion, the results of this research have shown that mid-sized European cities could be exposed to similar impacts of climate change including floods (pluvial, fluvial, or coastal), heavy storms, heatwaves, and, less markedly, the lack of water availability. However, the intensity of these impacts and the vulnerability of the territory varies from one case to another based on various factors, such as the geography of the territory (e.g., coastal vs. inland), the density of the built area, demographic factors (e.g., aging population and population growth) as well as the efforts of various actors in the city to take proactive and reactive climate actions. It is therefore essential to understand the specificity of each case to determine its vulnerability.

Vulnerability and impact assessments have been elaborated by various levels of governance in collaboration with experts, consultants, or academics the local universities. Nonetheless, there seems to be more knowledge at national and regional levels and at the scale of metropolitan areas and big cities. This underlines the need to develop more knowledge at a local scale, especially in the case of mid-sized cities.

Developing this knowledge in collaboration with various experts is a steppingstone, nevertheless the communication and the "vulgarization" of the produced scientific data are critical. In the examined case studies, despite the production of local impact assessments and the increased interest of the public in environmental and climate matters, many still seem to lack the understanding of how climate change could impact their daily lives. Climate change could be

perceived by many as far from their personal realm. The awareness and interest of the public seem to increase following the occurrence of climate events (e.g., heatwave or flood events) but is not always a constant as has been highlighted in the case of Rouen. People return to their habits and do things the way they are used to once the event is over. A behavioral and cultural change is therefore fundamental. The experiences of the selected cities exposed that including climate and environmental knowledge in the curriculum of schools and the practices of professionals could stir this cultural and behavioral change.

The occurrence of extreme climate events seems to have stimulated local governments to adapt the territory to climate change (e.g., the flood events in Nijmegen and Leuven, the heatwaves in Rouen, and the coastal storms in San Sebastian etc.). The visualization of the impacts makes the issue more real and personal urging responsible actors to act. However, “it has been shown that well planned, early adaptation action saves money and lives later” (European Commission, n.d.). Therefore, governments should not wait and respond reactively instead should develop proactive measures, based on the understanding of risks and vulnerabilities.

In addition to being exposed to environmental threats, various motivations seem to have pushed local authorities in mid-sized cities to address climate issues, it could be a legal obligation, or their personal conviction, the need to do things better, and seeing climate action as an opportunity to increase the livability of the city, attract investments as well as tourists. Regardless of the initial motivation to develop and implement adaptation measures, continuity and political commitments are crucial.

Given that the political mandate generally ranges between 4 and 6 years, elected mayors are under pressure to demonstrate performance in a short timeframe. Therefore, they tend to be interested in the implementation of short-term projects that have a fast return on investment as it could impact their chances of being re-elected. This however contradicts with the long-term time frame necessary for the implementation of adaptation actions to increase the resilience of the territory (Regional environmental agency of Normandy employee, interview, 2019).

Local elections could also lead to changes in the priorities that are addressed by the city council, affecting the budget dedicated for climate commitments. This stresses the importance of ensuring a stable political environment in which the continuity of adaptation efforts is not affected by local elections (e.g., case in Växjö), where all political parties have unanimously agreed to address environmental issues.

In addition to short-termism when it comes to conceiving a project for political reasons, the examined cases highlighted that the cities tend to implement short-term and small-scale initiatives to adapt to climate change for financial reasons. The results underlined that local municipalities in mid-sized European cities are facing a major challenge impeding the implementation of adaptation projects: the lack of financial resources. This problem affects the availability of adequate human and technical resources and hinders the development of big-scale projects that, in the short term, require larger investments.

Small-scale projects seem to require less capital such as the development of greening initiatives to increase the permeability of the soil and reduce the impact of heatwaves, the organization of environmental events, and the establishment of incentives to mobilize actors. However, as climate

change is expected to lead to major change and severe impacts, radical changes and the development and implementation of long-term and big-scale initiatives such as the room for the Waal project may be necessary. Adaptation requires systemic changes including transformations in social, legal, and political organizations, changes in individual patterns complemented by technological progress (Sokoloff, 2016).

To address the financial challenge, the results underscored that various funding initiatives are developed at a local, regional level national level (e.g., environmental budget, aids, crowdfunding initiatives), also funding schemes exist at a European level, however, there remains a need for easier access to these funding and efforts are required to make climate investments more attractive. The simplification of procedures (as the Dutch government did by approving a new environmental act), allowing to reduce bureaucracy, leaving room for general rules instead of detailed permits could incite the financing and development of innovative adaptation approaches and projects.

Local actors in the examined cases have highlighted that the public and various municipal actors across different departments are more familiar with notions of sustainable development and climate change mitigation rather than adaptation. In Rouen for instance, climate action is often seen or considered as restricted to issues of sorting and recovery of waste, creating cycling paths, limiting emissions, and increasing the share of renewable (Lesconnec, 2017). Other actions related to adapting the territory and increasing its resilience to climate change, remain unfamiliar to the public. To add to that, in developed environmental and climate policies, action plans tend to be focused on climate mitigation and fewer measures are proposed to protect the city from the impacts of climate change. Therefore, more efforts are needed to increase the knowledge of internal actors at the heart of the municipality as well as the public on the topic of climate vulnerability and climate adaptation.

Various initiatives and projects are in place to mobilize and implicate actors in efforts towards ensuring a participatory governance approach. However, results show that it remains a challenge to mobilize people with lower incomes as sometimes climate action requires personal investments. This raises the question of climate and social justice.

The results also underline the importance of ensuring the participation of residents in the decision-making and in the implementation processes to increase their awareness and ensure the acceptability of proposed projects.

The examined cities showcase that the monitoring and evaluation of adaptation measures are still at its embryonic stages, more research is required at this front. The issue is trifold. First, existing monitoring and evaluation systems are rather focused on mitigation. To add to that, the notion of monitoring adaptation is still blurred. Second, there is still a lack of a systematic approach to monitoring and evaluation of adaptation; some cities have adopted a qualitative approach to monitoring the status and the progress of implemented measures. However, it remains a challenge to develop quantitative indicators to assess the adaptability of the territory. Third, in some cases, the lack of the availability of figures, data, or information at the scale of a mid-sized city (as highlighted in the case of Leuven) is a challenge to ensuring monitoring and evaluation at a local scale (City of Leuven, 2017).

Results have shown that, despite uncertainties related to future weather events and impacts, some cities have developed a long-term vision and a flexible approach towards adaptation. These cities are following up on developed strategies and implemented measures to understanding the challenges as well as the success factors. This underlines the importance of developing a vision, the continuity of actions, and perseverance as well as the ability to learn from experience to increase the resilience of the territory to climate change.

In effort to increase the adaptive capacities of these cities, emergency services and concerned actors are mobilized to improve their response measures in the face expected and unexpected climate-related events, consequently, alert systems and contingency plans are developed to respond to forest fires, heavy storms, and floods.

Evaluating adaptation efforts increasing urban climate resilience is complex as various factors impact the response and the resilience of cities to climate events, including economic resilience, the resilience of built infrastructure systems, the psychological resilience of individuals as well the social resilience or the ability of local citizens to collectively cope and respond to stresses. This thesis develops an urban climate adaptation index from a governance perspective. In other terms, it considers the efforts of local authorities in place to increase the resilience of their territory to climate events.

The fact that “resilience” is not a static characteristic, increases the complexity of measuring or assessing adaptation effectiveness. This requires keeping data collection up to date, depicting the resilience at a given time. Additionally, the lack of data at the scale of mid-sized cities and “one-stop-shops” for climate-related research have made access to data and information difficult.

This thesis supposed that developing and implementing well-rounded climate adaptation policies increase the resilience of a mid-sized city to climate events as a starting point for further investigation. The results of this study showed that this is somewhat true. Yet Nijmegen presents an example of a mid-sized city that has a favorable climate adaptation governance system in place (based on the computed score in application of the developed urban climate adaptation governance index) yet does not have a proper adaptation strategy. Instead, the city has developed a thorough understanding of impacts and vulnerabilities, integrated adaptation measures and approaches in spatial development projects and implicated various actors of the territory in climate adaptation through its participatory governance approach. Whereas Rouen presents an example of a city that has developed a climate air-energy-territorial plan and is working on implementing adaptation measures (e.g., Ecoquartier Zac Luciline), however the city’s score evaluating governance efforts was the lowest among the examined case studies and that is due to the relatively weak understanding of impacts and vulnerabilities, coupled with the lack of resources necessary for the implementation of measures and the weak synergy between the different actors of the territory. This shows that the mere development and implementation of adaptation policies is not enough for increasing urban climate resilience. Developing an understanding of impacts and vulnerabilities, dissipating climate knowledge, implicating and mobilizing actors, ensuring the appropriate resources necessary for the implementation of measures, following up and monitoring on the progress of adaptation measures, understanding success factors and continuously adjusting adaptation policies in place are fundamental to increasing the resilience of a city.

The dissertation also presumed that the ability of a city to address climate issues is a factor of its scale, the governance system in place, and the priorities and the motivation of local authorities. The results have shown that, indeed, mid-sized cities could face some challenges when addressing climate adaptation issues, due to the lack of available data necessary for comprehending climate impacts as well as the lack of various resources needed for the implementation of measures. Nevertheless, mid-sized cities could offset challenges related to its scale by seeking funding as well as collaborating with supra-municipal levels and climate experts from the academic and the private sphere, while benefiting from the opportunities that could arise due to smaller lines of communication allowing to create synergies across various actors (e.g., establishing a city-wide organization, as is the case in Leuven). Not to mention, the scale of the territory and issues addressed at mid-sized cities seems to be more manageable and less perplexing than the problems faced by metropolises. The cities of Växjö and Nijmegen are examples of mid-sized European cities that are frontrunners in the governance of adaptation proving that the scale of the city does not inhibit it from taking climate action. Yet in this case in particular, local authorities enjoy a great deal of independence in decision making and have the political will to address environmental and climate issues. Whereas, in contrast the city of Rouen with a centralized governance system, supra-municipal levels seem to have more “power” to act while adaptation needs to be addressed at a local scale. This attests that the city’s motivation and its political will coupled with a stable political environment -ensuring a city’s long-term commitment- seemed to be determining factors to increasing a city’s adaptive capacity and its climate resilience. It also calls for empowering local authorities to address climate issues at a local scale and ensuring the availability of adequate resources.

6.3 Recommendation for Further Research

Further research should give more attention to mid-sized cities, especially that cities of the scale host the largest share of the urban population in Europe (Giffinger et al., 2007), are impacted by climate change, and present challenges and opportunities in addressing the topic.

The proposed index may be used to assess the adaptation of any mid-sized European city to climate change due to governance efforts. Its application to a larger number of cities of similar scale may allow for the benchmarking of efforts and an improved understanding of the challenges that are common to all, and for a better determination of success factors.

While monitoring mitigation efforts seems to be more defined and accurate, monitoring adaptation targets is still relatively blurred and unclear. Therefore, research is required at this front, investigating what qualitative and quantitative indicators should be used to monitor adaptation targets. Additionally, further research should be conducted to investigate the potential of the development of a unified monitoring and evaluation system that could be used by all cities to assess the performance of implemented adaptation projects.

Researchers could investigate the potential of developing one-stop-shops for data collected at a city scale including environmental data. They could explore how cities could build a dependable, updated, and searchable database that could be used as a basis for policy and decision-making.

It is also interesting to examine the benefits and risks of endorsing an open data policy at a city scale, assuring an improved access to public data, and allowing all key stakeholders to use the same information to design innovative adaptation solutions and improved development.

To end, more research is required to explore different approaches that a city could use to reach out to underprivileged and lower-income groups and get them to commit to climate action. This issue has been underlined by the cities of Nijmegen and Leuven, especially that climate adaptation could result in additional expenses and require personal investments and dedication.

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APPENDICES

Appendix I: Key Concepts and Interviews

I.1 Key Concepts

To develop a focused thesis, the following key concepts adopted in this research study are defined as follows.

- **Medium-sized cities:** This research adopts the Covenant of Mayor's classification of medium sized European cities with urban centers hosting between 50,000 and 250,000 inhabitants given that this platform is used as a basis for the selection of case studies.
- **Climate Change:** This thesis considers the UNFCCC's definition which refers to the modification of the global atmospheric composition as a result of the indirect or direct human activity (UNFCCC, 2015). The occurrence of seasonal meteorological events does not necessarily imply changes of climate. According to the ADEME (2018), at least 30 years of observations are needed to define characteristics of climatic order.
- **Impacts of Climate Change:** Referring to the negative and positive consequences of the alteration of climate conditions. These impacts vary considerably across regions and could present opportunities or expose communities to considerable levels of threats such as the increased frequency and intensity of extreme weather conditions and the rise of sea level (NASA, 2021).
- **Climate Governance:** This research considers climate governance as the set of response measures, mechanisms as well as the diplomacy developed to steer social systems towards mitigating, preventing, or adapting to climate risks (Jagers & Stripples, 2003).
- **Adaptation Strategies:** This study considers adaptation as the processes of preparation which allows a city or a region to overcome negative impacts while benefiting from opportunities and potentials arising consequent to the alteration of climate conditions (Füssel, 2007; the World Bank, 2011).
- **Adaptive capacity:** This thesis adopts the Climate ADAPT's definition which refers to the ability of systems to adjust and to cope with the implications of climate change. This capacity is a function of risks, varies between sectors and depends on the availability of financial and human resources.
- **Urban Resilience:** Defined by 100 Resilient Cities as building and improving the capacity of cities to adapt and transform to withstand both unexpected and projected events and respond rapidly. "The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience" (100 Resilient Cities, n.d.). In this research we are focusing on the ability of cities to overcome the negative impacts of climate change without elaborating on other stresses or shocks which could face cities such as earthquakes, terrorist attacks, pandemics or other.
- **Participatory approaches:** Defined by the European Environment Agency in its report No 8/2009 and No 3/2013 as the reinforcement of the representation and involvement of various stakeholders in the decision making with clear assignments of tasks and responsibilities.
- **Mainstreaming of Adaptation:** Defined by the European Commission as the incorporation of adaptation measures into governmental policies, decision making and development plans in various sectors to ensure a reduced sensitivity to impacts of climate change.

- **Monitoring and Evaluation:** Defined by the French Environment and Energy Management Agency (ADEME), as the use of qualitative and quantitative data to determine whether the climate action in place is efficient and successful. This process provides information to main stakeholders to allow them to improve the decision-making process (ADEME, 2013).

I.II Interview Questions

For the collection of primary data, key actors and stakeholders have been defined for each of the case studies. Semi-structured interviews are conducted with these actors allowing for the understanding of the reality of the situation in the examined cities. General interview questions were developed, as presented below, then for each of the cases more specific questions were addressed.

- Is the city/region already dealing with impacts of CC? or the impacts are mainly projections that are likely to occur in the future?
- Are there documented or published studies on the impacts of CC on the region? If yes, are they recent? are there any plans to update them based on new insights? If no, are there any plans to develop impact assessments/studies?
- Are there any research or studies conducted to improve the understanding of impacts of climate change in this region/city and to close knowledge gaps? (improving gov in place)
- Are regional/local authorities aware of the importance of adapting the territory to impacts of climate change?
- What are the impacts that should be urgently addressed in the region/city and are considered of high priority?
- Are there areas that have not been considered at all in the regional/local adaptation strategy or areas requiring more attention?
- To what extent is the regional strategy aligned, coordinated, and supported by local municipalities? How is this coordination insured?
- Does the regional/city's adaptation strategy include mid-term and long-term plans on the horizon 2050 and does it take future uncertainties into account?
- Is the policy flexible enough to be adjusted or redirected at acceptable costs based on new insights?
- Who was involved in the definition of the climate adaptation strategy and its action? What actors? From which sector?
- Is the regional/local adaptation strategy regularly updated? If yes, is it updated based on recent impact assessment and improved understanding?
- Does the regional/local government offer financial and material resources to ensure the implementation of adaptation measures?
- Does the region/city play a role in the monitoring and evaluation of implemented adaptation measures?
- What methodology is used for monitoring and evaluation? Are there specific indicators? What are these indicators?
- What are the sources of data used for monitoring?
- In your opinion, what are the success factors for adapting the region/city to climate change?
- According to you, what are the obstacles and challenges that the region/city is facing in the implementation of adaptation measures?

I.III List of Interviewees

As this thesis is written with respect to ethical principles, it values the confidentiality of the interviewees. Therefore, the names of interviewed actors are masked all through this research in respect of their right to privacy and right to freedom of expression. Only the function of the interviewee is stated as it has scientific relevance.

City	Interviewees and function	Date
Rouen	Climate researcher at the University of Rouen	May, 2019; July, 2021
	Métropole Rouen Normandie employee at the directorate of environment and energy	May, 2019
	Municipality of Rouen employee in charge of ecological transition	May, 2019; July, 2021
	Municipality of Rouen employee at the directorate of attractiveness and living environment	May, 2019
	Regional environmental agency of Normandy employee	May, 2019
	Rouen Cit'ergie consultant	May, 2019
Nijmegen	Environmental researcher at the Radboud University	October, 2020; June, 2021
	Adaptation policy advisor at the municipality of Nijmegen	November, 2020
	Climate adaptation strategist at the province of Gelderland	November, 2020
	Nijmegen Climate consultant	June 2021
Leuven	Alderman in the board of mayor at the city of Leuven	December, 2020
	Associate at the Flemish Environment Agency	May, 2021
	Environmentalist and researcher at the KU Leuven	May, 2021
	Leuven municipal councilor representing the Green party	November, 2020; July, 2021
Växjö	Associate at the administrative board in Kronoberg County	June, 2021
	Environmental strategist at Växjö municipality	September, 2020
	Member of the Växjö climate commission	August, 2020; June, 2021
	Sustainability administrator at Växjö municipality	June, 2020; June, 2021
	Swedish politician serving the Växjö Municipality	June, 2020
San Sebastian	Associate at the Public Society for Environmental Management of the Basque Government - Ihobe	June, 2021
	Environmentalist at the San Sebastian City Council	February 2021; June 2021
	San Sebastian Climate consultant 1	January, 2021
	San Sebastian Climate consultant 2	January, 2021
	San Sebastian climate expert	February, 2021
Independent experts	Associate at the International Centre for Climate Change and Development ICCCAD	May, 2018
	Expert on Climate change vulnerability and resilience in urban centers at the IIED	June, 2018

Table 5 List of conducted interviews for primary data collection presenting the function of interviewees and the date of the interview.

Appendix II: Climate and Adaptation plans

II.1 City of Rouen Climate-Air-Energy Action Plan (2017-2021)

Defining priority levels

1	High priority
2	Medium priority
3	Low priority

Priority level	Action	Mitigation / Air pollution	Adaptation	Sustainable Development
1	Continue to implement the parking policy.			
1	Mainstreaming the consideration of the Climate Air Energy theme, including adaptation, and integrating the concept of environmental compensation into town planning operations.			
1	Develop an energy supply strategy, in connection with the future metropolitan PCAET and support the Metropolitan Energy Master Plan.			
1	Formalize and implement an Energy Management System (EMS) relating to the City's heritage.			
1	Instill an administrative culture of Sustainable Development through the concretization of the actions undertaken and initiate a process of Corporate Social Responsibility.			
1	Promote the development of renewable energies in the region and more particularly solar photovoltaic.			
1	As part of the development of the Ecoquartier Luciline, in conjunction with CEREMA, carry out a diagnosis and recommendations relating to biodiversity, uses and heat loss from buildings.			
1	Develop incentive actions in favor of the fight against fuel poverty.			
1	Launch an experiment on user participation in energy performance.			
2	Support the Metropolis in the implementation of the "Breathable Cities" action plan including the "Manzana" experiment at the level of the St-Hilaire district.			
2	Carry out the exemplary energy renovation project of the Town Hall.			

2	Define a specific communication plan on sustainable development and organize an event during the sustainable development week.	Blue	White	Green
2	Make an inventory of the indoor air quality in City buildings and implement corrective actions (nurseries, schools, leisure centers).	Blue	White	White
2	Continue to educate school audiences about the environment and Sustainable Development including energy saving programs.	Blue	Orange	Green
2	Implement the "well-being around meals" project based on the "my responsible restaurant" approach.	White	White	Green
2	Develop an incentive program for Rouen families towards low carbon impact practices.	Blue	White	Green
2	Support the development of urban gardening and all forms of revegetation.	White	Orange	White
2	Develop a management plan for Sainte-Catherine Hill in conjunction with the MRN.	White	Orange	White
2	Support the establishment of a solidarity restaurant.	White	White	Green
2	Generalize the principle of the reform of the parking lots of the Town Hall to the sites of the right bank hyper-center.	Blue	White	White
3	Participate in the local COP 21 and coordinate Metropolitan and City actions on the theme of energy and Climate.	Blue	Orange	Green
3	Develop a biodiversity plan for urban and natural environments in conjunction with the MRN and the Environment - Biodiversity Commission.	White	Orange	White
3	Continue and improve the consideration of sustainable development criteria and the climate / energy theme in the implementation of the participatory budget of neighborhood councils.	Blue	Orange	Green
3	Formalize a responsible purchasing procedure in the purchasing process.	White	White	Green
3	Mobilize the economic players of the territory (organize one event per year on the climate / energy theme) and participate in one exchange per year with European partners.	Blue	Orange	Green
3	Continue the restructuring of urban green spaces (parks, gardens, etc.) and the implementation of the differentiated management plan for these spaces.	White	Orange	White
3	Gradually introduce criteria and recommendations for sustainable development in the assistance provided to	White	White	Green

	associations (financial assistance and assistance in kind), towards more eco-responsibility.			
3	Deploy an eco-gesture approach accompanied by an awareness campaign through "tutorials" and continue actions to reduce consumption or use of eco-labeled products in services.			
3	Boost the pedibus (which is a family mode of public transport designed based on a pedestrian school bus system) according to parents' demand, promote existing initiatives.			
3	Preserve water resources and reduce the city's drinking water consumption.			
3	Go beyond the applicable thermal regulations and study the possibility of using renewable energies for each new renovation and construction.			
3	Promote soft mobility through the co-development of street code and creation of practical communication tools			
3	Use events to raise awareness of sustainable development and systematize the consideration of sustainable development in the organization of all events.			
3	Study the possibility of making the city's electric vehicles accessible to Rouen residents.			
3	Propose a 'work from home' development strategy.			
3	Apply the charter of green worksites to City operations with the aim of extending the system to the entire territory.			
3	Continue experimentation with energy performance contracts on buildings.			

Table 6 City of Rouen Climate-Air-Energy Action Plan (2017-2021) as presented at the municipal council on April 9, 2021.

II.II Metropole of Rouen Climate-Air-Energy Action Plan (2019-2024)

Policy	Climate	Air	Energy	Adaptation
Develop a public service for the energy renovation of houses.				
Support the renewal of heating devices.				
Support and accompany the energy renovation of tertiary buildings.				
Support the construction or extension of low-carbon buildings and bioclimatic design.				
To appease traffic on the scale of the territory.				
Create a Living Lab Rouen Mobility.				

Rationalize the road accessibility of the territory.	Green	Yellow	White	White
Consolidate the performance and attractiveness of the urban mass transit system.	Green	Yellow	Blue	White
Promote the use of active transportation modes.	Green	Yellow	White	White
Promote sustainable mobility for employees working in the territory of the Metropolis.	Green	Yellow	White	White
Connect the different transportation networks.	Green	Yellow	White	White
Develop digital tools for sustainable mobility.	Green	Yellow	White	White
Promote carpooling and the sharing of private vehicles.	Green	Yellow	White	White
Promote the use of low-carbon vehicles.	Green	Yellow	Blue	White
Share knowledge of mobility practices to raise awareness and mobilize the actors of the territory.	Green	Yellow	Blue	White
Accompany the actors of the territory in the development of renewable energy projects.	Green	White	Blue	White
Structure and develop wood energy systems.	Green	Yellow	Blue	White
Structure and develop heat recovery systems.	Green	Yellow	Blue	White
Structure and develop solar systems.	Green	White	Blue	White
Structure and develop the production of renewable gases.	Green	Yellow	Blue	White
Structure and develop energy distribution networks.	Green	White	Blue	White
Improve knowledge and communication around "air" issues.	White	Yellow	White	Green
Promote sustainable urbanism.	Green	Yellow	Blue	Green
Develop exemplary urban projects.	Green	Yellow	Blue	Green
Improve the knowledge on the local impacts of climate change.	White	Yellow	White	Green
Preserve water resources.	White	White	White	Green
Prevent and protect against flood risks.	White	White	White	Green
Preserve local biodiversity.	White	White	White	Green
Develop a quality sustainable food supply that is accessible to all.	Green	Yellow	White	White
Support sustainable, innovative, and integrated agriculture practices.	Green	Yellow	Blue	Green
Promote forest management at the scale of the territory.	Green	Yellow	White	Green
Promote the role of carbon storage in agricultural, forest and natural environments.	Green	Yellow	White	Green
Support the economic actors of the territory in the "zero waste" approach.	Green	Yellow	Blue	White
Carry out the Rouen Accord for the climate.	Green	Yellow	Blue	Green
Support municipalities in their energy and ecological transition.	Green	Yellow	Blue	Green
Promote the participation of citizens.	Green	Yellow	Blue	Green
Foster decentralized cooperation and international solidarity.	White	White	White	Green

Promote energy performance and the development of renewable energies within the heritage of the Metropolis.				
Promote sustainable mobility within the services of the Metropolis.				
Integrate environmental criteria into the internal functioning of services.				
	35/40	33/40	21/40	14/40

Table 7 Actions to be undertaken by the metropolis of Rouen between 2019 and 2024, in the context of the PCAET, to mitigate climate change, improve air quality, promote the use of renewables, and adapt the territory to changes of climate.
Source: Métropole Rouen Normandie & COP21, 2018.

II.III Province of Gelderland Climate Adaptation Action Plan (Case of Nijmegen)

Theme	Budget	Areas of Action	Measures
Natural soil and water system as a basis	€750,000	Producing knowledge	Improving information about climate effects by conducting research in collaboration with other provinces and universities. Measuring the effects of implemented measures on the functioning of natural systems and its efficiency in making an area climate-proof.
		Applying knowledge	Putting into better use the existing knowledge about different systems (e.g., take better account of the properties of the subsoil to make neighborhoods climate adaptive.). Working together with various partners on approaches to address existing problems (e.g., knowing that sandy soils are vulnerable to drought, it is important to use the acquired knowledge to adapt the soil to the consequences of extreme weather).
		Inspiring action	Collaborating with the Wageningen university to draw up a long-term vision.
			Sharing good examples through the network organization of Gelderland municipalities, environmental services, water boards and the province.
Green cities and villages	€750,000	Challenging green icon projects	Challenging municipalities, entrepreneurs, landscape architects, project developers and landowners to transform mineralized surfaces of at least 1,000 m ² into green, iconic, public places.
		Planting trees in built-up areas	Planting 1 million trees outside the Gelderland Nature Network (part of the Tree and Forest Implementation Program).
		'Greening' subsidy schemes	Applications with greening measures receive a bonus in the form of a higher subsidy amount or are a condition for applying for the subsidy.
		Researching 'Climate-proof greenery in the city'	Mapping out the relationship between urban greenery, water management, drought, and heat (to determine which species to plant).
		Greening the agenda and	Organizing meetings, sharing knowledge and practical tips for municipalities, entrepreneurs and

		knowledge sharing	other interested parties to inspire them in making their living environment greener.
Climate-proof (re)building	€ 1.000.000	Location selection	Take better account of the effects of climate change when choosing locations for new urbanization to limit the risks of building in less suitable places (i.e., mapping out the risks).
		Layout area	Looking for practical tools to include climate adaptation in new development locations (e.g., the Clean Tech pilot).
		Building and immediate surroundings	Stimulate knowledge development, especially regarding heat stress (e.g., join forces with leaders in the field of construction, establishing learning network initiatives etc.).
Climate-proof provincial roads	€ 500.000	Developing an Ambitionweb Sustainable Ground-Road and water services (Completed in 2019)	Tendering the work based on the ambitions that have been agreed with the ground-road-water sector. (Climate adaptation is one of those ambitions).
		Developing an atlas for impact atlas on Gelderland infrastructure (completed in April 2021)	This atlas maps the effects of climate change (flooding, heat, drought, flood risks) on the infrastructure of Gelderland and underlying assets.
		Embedding climate adaptation in trajectory programming	Using the climate effect atlas to map out for each trajectory the effects and the risks. This shows whether measures are necessary, such as the replacement of culverts or the purchase of land along roads for water storage.
Heat stress	€ 2.000.000	Raising awareness by putting the topic on the agenda	By organizing events to raise awareness (e.g., heat week event), establishing a platform to show various actors of the territory good examples and discuss measures, and developing initiatives to encourage residents to act to adapt their own home, garden, and environment to the changing climate.
		Connecting smartly with other provincial tasks	As we describe in the previous themes, greening and climate-adaptive (re)building. A good example of generating attention for heat is the challenge "My house is in Gelderland".
		Doing and funding research	Conducting a Heat Perception Survey among tenants of housing associations to gain more insight into how residents (users) experience heat and what measures have been taken. And what additional measures can be taken in the area, building and by the user. Mapping out the resident's cooling needs and the effects of various possible measures.

		Co-financing measures	Supporting municipalities in taking steps on this theme. Both in collaboration and in concrete projects.
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Table 8 Climate Adaptation Action Plan (program) towards a climate-proof Gelderland Coalition. Source: Province of Gelderland (2021).

II.IV Leuven's Climate Action Plan (2020-2025)

Areas of Action	Measures	Actions
Integrated urban climate policy	Integrated urban policy	Expand urban organization.
		Setting up a climate team and innovation teams.
	City-wide collaboration	Expansion of Leuven 2030.
		External representation.
		Focus on city-regional cooperation.
		European collaborations.
	Innovative financing	Establishment of a climate fund.
		Support citizen cooperatives.
		Set up an ambitious external financing through fundraising.
	Monitoring	Setting up a systematic data collection.
		Follow-up of projects via ORBA, an analytical job evaluation method.
	Exemplary function, city-wide, communication and awareness-raising	The city is acting as an example and involves the entire operation in climate policy.
The city communicates about climate policy in an activating way. The city is developing a comprehensive approach for this.		
Inclusive and participatory operation	Attention to an inclusive climate policy.	
	Attention to a participatory effect.	
Urban heritage	Drawing up an energy management plan	Approve and sign framework agreement with Fluvius which is responsible for the construction, management, and maintenance of distribution networks for electricity, natural gas, sewerage, and heat, and manages the municipal public lighting park.
		Consultation with Fluvius.
		Collect information for the Energy Management Plan.
		Fluvius guidance during building visits.
		Drawing up the Energy Management Plan.
		Energy Management Plan analysis.
		Checking planned and current projects against the Energy Management Plan and adjust where necessary.
		Selection of concrete actions from the Energy Management Plan.
	Drawing up an estate policy plan	Energy Management Plan analysis.
		Analysis of further needs for a Patrimony Management Plan.
		Make a choice as to whether the municipality has the Patrimony Management Plan made (via public contract) or whether it develops it on its own.
		(supervision) drawing up of the Patrimony Management Plan.
		Collect information for Asset Management Plan.
		Analysis of the Asset Management Plan.
		Communicate and set up asset management plan as a guideline for every project and project application.
		Permanent analysis, follow-up, and adjustment of the Asset Management Plan.
		Create checklist and integrate into workflow.

	Integrate sustainability principles into workflow for urban building projects	Awareness / integration of the checklist among those involved colleagues.
		Expanding knowledge about adaptable, maintenance-friendly, reversible and sustainable designs.
		Permanent follow-up / addition of this workflow.
	Monitoring and optimization of building management systems in urban buildings	Making an overview of all building management systems in the buildings, looking at which parameters are interesting to monitor.
		Set up temporary or permanent loggings for interesting data.
		Analyze data.
		Analyze which adjustments to the building management system should be done.
	Further expansion of the telemetry system	Adjustments carried out by our own services and /or if necessary, issue an assignment for adjustments by third parties.
		Analysis of existing telemetry system and layout of planning further rollout in buildings that do not yet have telemetry.
		Drawing up energy flow diagrams for buildings where the basic counters are already installed.
		Identification and selection of interesting additional intermediate meters.
		Installation of additional intermediate meters in buildings.
		Analysis of telemetry data.
	Pursue efficient use of space	Detection of possibilities for improvement and initiation of improvement projects, as part of the Energy Management Plan and / or Patrimony Management Plan.
		Optimizing workgroup space questions (eg via database).
		discuss city-wide with every strategic infrastructure project what needs / opportunities there are.
		Making the supply and demand of spaces visible throughout the city (at a later stage).
	Future ambition regarding making the urban heritage more sustainable	Drafting spatial guidelines for workplaces.
		Renovation of existing city buildings (to decrease of electricity and energy consumption).
		Build new climate neutral buildings and use circular materials as an important element in the new construction of city buildings.
Reducing emissions and assure a sustainable purchasing policy	Assure the sustainability of heritage buildings.	
	Making public lighting more sustainable	
	Drawing up a master plan.	
	Implementing projects.	
	Use green electricity	
	Purchasing green electricity.	
	Implementing projects to produce green electricity and green heat.	
Greening the fleet	Purchase of more environmentally friendly vehicles.	
	Developing a sustainable travel policy.	
	Purchase environmentally responsible products.	
Circular and sustainable materials	Product-service systems.	
	Circular materials.	
Sustainable Urban Development	Sustainability framework	Layout framework for sustainable urban development with impact calculation, spatial energy planning.
		Strengthening of regulations and accompanying instruments.
	Making developments of major actors or specific target	Agreements memorandum on making social housing more sustainable.
		Collaboration in projects on industrial estates.

	groups more sustainable	
(Residential) buildings	Development of a one-stop-shop (energy house)	Bringing partners together.
		Setting up a legal structure.
		Campaigns on supply from energy house.
		Seek financing for an energy house and distribute it correctly.
		Effective accompaniments.
	Innovative financing for energy renovation	Overview of existing financing options per type of building, works and target group and listing of gaps in this.
		Search for additional financing options from higher authorities, the financial sector and other organizations.
		Urban offer to supplement existing and new financing options.
		Urban grants in function of specific financing needs.
	Apartment buildings	Mapping needs, thresholds, and solutions for high-quality apartment renovations.
		Development and testing of a high-quality support offer.
		Sustainable cooperation with syndicates.
		Campaigns to make apartment buildings more sustainable.
		Provide funding for guidance of associations for co-owners.
	Vulnerable target groups	Mapping needs, thresholds, and solutions for high-quality and sustainable housing solutions.
		Set up an intensive counseling process that starts from the three target groups mentioned, and provides an integrated approach.
		Set up a structural collaboration between the partners involved.
		Provide funding for guidance for this target group.
	Collective (district) renovations	Conceptualizing a neighborhood energy transition.
		Converting concept into action plan.
		Parameters and selection criteria for district + selection.
		Participation process with neighborhood.
		Individual guidance to increase participation rate.
Operational rollout of neighborhood energy transition.		
Renewable energy	Drawing up an energy strategy	The city draws up an energy strategy that divides the territory of Leuven into districts from the point of view of energy typology and maps the possible strategies at district level to drastically reduce CO2 emissions from heating buildings.
		Prior to major urban developments, a sustainable heat test is carried out.
		Energy concepts for neighborhoods are drawn up.
		Projects are set up within the framework of the energy strategy.
	Maximize energy production through solar energy	Make the roofs of Group Leuven's patrimony available as much as possible to produce solar energy.
		Setting up awareness campaigns towards private individuals, schools, associations, companies.
		Facilitating the local energy cooperative in developing solar projects.
		Urging the higher government for more flexible legislation on solar installations and making solar parts possible.
	Maximize energy production through wind energy	Urging higher authorities to remove barriers.
		Set up a city-regional operation on wind energy.
		Remain active on the potential and technology of smaller turbines follow up.
		Screening and valorization of the entire group assets

		Leuven. Invest yourself in wind projects outside Leuven, for example, off-shore, and also involve the people of Leuven in this.
	Exploration project smart grids and energy storage	The city is investigating the potential of smart grids, neighborhood batteries, local energy communities, etc. in one or more pilot project projects.
	Directing and facilitating pilot projects on green heat	The city is committed to and takes on a directing role in several key green heat projects that arise from the energy strategy.
	A city-regional energy cooperative	Support and facilitate the operation of the cooperative.
		Actively identify opportunities for cooperatives realizations. Communicating and recruiting in function of specific projects.
Food	Promotion of sustainable and healthy food	Communication of campaigns via city channels or own website food strategy.
		Communication with cooperation of partners.
		Organization of events around local and sustainable food.
		Allowance regulations for projects in the context of the implementation of the food strategy.
	Scaling up short-chain sales and setting up a suburban distribution platform	Collaboration agreement with Kort'om Leuven (suburban distribution platform). Participation in the board of Korto Leuven.
	Making agriculture more sustainable	Collaboration with innovation support point, Generation Food.
		Setting up pilot projects.
Participation in Horizon 2020.		
Avoid food losses	Using public space for urban agriculture.	
	Setting up a platform for redistribution of food surpluses. Study and action plan on food loss in households.	
Waste - Circular economy	Strengthening waste prevention and making waste processing more sustainable	Expansion of the container parks into recycling parks.
		Organize waste prevention initiatives.
		Optimizing selective collection.
		Start-up of the Leuven Circular platform with relevant urban actors.
		Using that platform, develop a first urban circular strategy, follow it up and refine it.
		Develop an interim update of the strategy with more concrete objectives and instruments.
	Circular entrepreneurship in Leuven	Develop an interim progress report on the implementation of the strategy.
		Strengthen knowledge and networking around the circular economy at the Leuven companies and integrate it into operations.
		Identify and utilize economic opportunities for circular employment based on insight into material flows and consumption patterns in the city.
		Use available expertise at the university and supra-local networks for new economic initiatives (eg start-ups, high-tech manufacturing industry).
		Taking advantage of opportunities to offer new circular perspectives for precarious employment (role of the social economy, opportunities for the low-skilled, ...).
Integrate circular principles in the choices for and organization of business sites and space.		

	Circular construction in Leuven	Collect and support the actors involved in construction in Leuven around the principles of circular construction.
		Build or support circuits that collect and reuse building materials within the Leuven region (create conditions for better 'urban mining' by developing a 'harvest map' and adjusting applicable procedures and instruments).
		Start or prepare pilot projects for circular construction (materials passport, adaptable and modular construction, reuse of buildings, project for Green Deal ...).
		Prepare strategic project of an urban materials bank.
	Recover, share and reuse	Create a favorable climate for citizen initiatives around repair and the sharing economy.
		Stimulate knowledge building and network formation to scale up product repair (executing Sharepair).
		Further embedding the social economy structurally in a circular strategy.
		Starting up innovative projects aimed at valorizing interesting waste flows.
	Sustainable and circular consumption	Towards a sustainable and circular handling of clothing (fair fashion, slow fashion, circular fashion, ...).
		Original campaigns to encourage sustainable consumption behavior and support good practice in local trade.
		Elaboration of a charter and actions.
		Mapping of barriers encountered by traders and citizens towards a culture of sustainable consumption.
	Develop knowledge and embed circular principles in policy in a sustainable way	Mapping the urban material flows and consumption patterns through scientific research with the aim of optimally focusing the urban strategy on the most promising elements and following up the implementation of the policy as closely as possible and adjusting it if necessary.
		Stimulating knowledge development to make the best possible use of the economic potential of the urban circular economy.
		Elaboration of a Leuven Circular City strategy (based on the administrative memorandum) and a 'Leuven circular platform' with partners who help shape and monitor the implementation of that strategy.
		Drawing up a landscape map that provides an overview of the urban circular ecosystem (who is already working on circular initiatives or is planning to do so).
Development of a follow-up system to monitor the implementation of the strategy.		
Preparing the update of the urban strategy.		
Embedding circular principles in the city's purchasing policy and other urban actors.		
Optimizing the various policy instruments and the policy culture (Regulations, permits, levies, integration of circularity in the various action plans, transversal operation of the services...) to support circularity.		
Collaborate with other cities in learning networks		
Attracting supra-local subsidies in function of the strategic ones, objectives and relevant cooperation programs.		
Mobility	Mobility planning	Pioneering role in city-regional cooperation in mobility policy and the Regionet project.

		Working on a mobility plan for the entire territory.
		Elaboration of mobility plans for municipalities.
		Development of a monitoring system to monitor and follow up on the evolution of travel behavior in Leuven (biannual survey of travel behavior, network of permanent counting points, ...).
	Leuven bicycle city	Continue to implement the Leuven bicycle policy plan. Realizing bicycle streets, residential areas, car-free routes. Expanding the bicycle infrastructure, bicycle highways and missing links. Bicycle highways improve routes to low-traffic neighborhoods and alternative low-traffic areas. Elaboration of a bicycle parking policy, with neighborhood bicycle parking facilities, temporary parking facilities at events, bicycle guidance at large parking facilities, differentiation of parking duration, ...Stimulating bicycle use by means of campaigns. Expanding the share of shared bicycles.
	Public transport	Elaboration of Regionet and Network Plan 2020-2025.
		Realization of the Ringplus route.
		Autonomous bus shuttle connection.
		Optimizing the third-party payer formulas.
		Communication campaigns on public transport.
	City logistics	Increase accessibility to bus stops.
		Development of a network of smart lockers at neighborhood level at the Mobipoints (at least 10).
		Partner in Green Deal Smart City Distribution.
		Development of the city distribution platform "Leuven Provides", which is the "burden organizes mile 'deliveries.
		Zero-emission urban distribution charter.
		Partner in the short-chain distribution platform for food "In short" Leuven ".
	Shared Mobility	Further development and exploitation of the Ecowerf loading and unloading framework.
		Update car sharing plan.
		Developing a regulatory / quality framework for bicycle sharing and license bicycle sharing providers who comply with this.
		Third-party payment scheme to stimulate the use of licensed shared bicycles.
		Promotion and support of various forms of car sharing via cooperation agreement with Autodelen.net.
Development of Mobipoints.		
Promotion and awareness-raising about car sharing.		
MaaS: follow up within the Transport Region and draw up regulatory frameworks.		
Greening mobility	By 2025, all public car parks will be equipped with a sufficient supply of charging points.	
	By 2025 there will be at least 100 public charging points in Leuven.	
	The city of Leuven is committed to greening its own vehicle fleet.	
	Taxi regulations and roll-out of fast charging infrastructure ensure a transition to 100% emission-free pitch taxi fleet by 2030.	
	The city of Leuven uses 100% electric bus shuttles for her peripheral car parks.	

		The city of Leuven is urging De Lijn to complete its bus fleet greening.
		Introduction of a low emission zone for the Leuven region (to be agreed within the Transport Region Council by 2025).
Climate Adaptation (Greening + heat control)	Reinforce blue-green main structure	A "Master Plan" for the Dile Valley and strategic project for the Molenbeek Valley Green plan and updating GNOP (Green Management Department - Wim Verheyden).
	Greening of the city	Conservation and expansion of the green area.
		GIS analysis on the potential of additional street, avenue, square and park trees.
		Annual planting of new street, avenue, square and park trees (in connection with a substantial expansion of the tree stock), without losing sight of the added value of other biodiverse vegetation (ecosystems).
		Elaboration of a protection plan for trees.
		The added value of all kinds of "nature-based solutions" (nature-based solutions or green solutions) is optimally integrated in its own urban projects and on and around its own heritage.
		These green solutions are also promoted to external partners and citizens.
		Implementing "Green functional experience trajectories" in the framework of the improvement and expansion of the cycling and walking infrastructure and the active city (see also chapter mobility).
		Supporting the greening of buildings (and other "nature-inclusive building" measures).
		Implementing a Biotope Area Factor (or the Biotope Area Factor (BAF)) in the permit policy.
		Implementing a green standard (for urban development projects).
		Introduction of a biodiversity test for developments in certain city districts.
		Collaboration with nature associations and support the greening of semi-public and private spaces.
		Multifunctional greenery and nature development
	Nature development is linked in the management of all green zones and is also stimulated in business parks, agricultural areas, etc.	
	Food production in green areas is stimulated where possible.	
	Sustainable management of Historic Gardens is supported (partly because of the preservation of old voluminous trees that are so important in counteracting the heat island effect in the summer months).	
	CO2 capture in green spaces	GIS analysis of the potential for CO2 storage in green spaces: peat, forest expansion, permanent grasslands, small landscape elements such as hedges and wood edges, agroforestry ...
		Planting new neighborhood forests and planting forests in the context of (re) afforestation and / or forest expansion.
		Start-up of "agroforestry" projects on the territory of Leuven
Start-up or "agroforestry"	Investment projects from the rainwater plan are carried out, e.g., rain squares, WADIs, buffer basins, ...	

	projects on the territory of Leuven	The policy framework for water management is adjusted on the basis of the rainwater plan.
		Watercourse management is being adjusted.
	Softening the city	Softening own sites and stimulating the softening of private sites
		Adjusting the regulations in spatial policy and water policy to achieve water-neutral development.
		Greening of the core shopping area.
	Prevent Drought	Elaboration of an action plan based on a drought study and rainwater plan.
		Including drought control in the construction and management of public domain and greenery.
		Adjusting the regulations regarding urban developments and well-depletion.
		Starting up projects to combat the consumption of groundwater, in own heritage, green management, homes and businesses, agriculture, etc.
	Counteract heat island effect	Elaboration of a heat plan.
		Inclusion of heat island in energy coach project.
		Addressing heat island effect in the construction of public domains.
		Addressing heat island effect in residential projects.
		Developing specific communications and measures in case of heatwaves.

Table 9 Actions and measures proposed by the city of Leuven in its climate action plan (2020-2025). Source: City of Leuven, 2020.

II.V Växjö's Adaptation Action Plan

1	Existing major problems, work needs to be done / intensified immediately.
2	Can see effects today that will escalate according to the models available. work should be done within the closest years.
3	Future expected effects that need monitoring.

Area	Adaptation Measure	Responsible party	Priority level
<ul style="list-style-type: none"> Organization 	Develop investment plan (s) for stormwater operations.	Technical Committee	1
<ul style="list-style-type: none"> Organization Urban Heating Human Health 	Areas that are important from an urban heating and stormwater perspective should highlighted in the green structure program and in regular planning work.	Municipality / Technical Committee	1
<ul style="list-style-type: none"> Human Health Electrical system, heating and cooling requirements 	Develop an action plan to maintain normal indoor temperature (mainly for vulnerable groups such as children, the elderly and seriously ill) in times of high temperatures.	School and childcare / Care homes / Corporate boards	1
<ul style="list-style-type: none"> Buildings and Constructions 	Complete inventory of calculated maximum flow and develop guidelines for future development.	Technical Committee / Municipality	1
<ul style="list-style-type: none"> Human Health 	Inform the public about the health effects of heat (waves) in a changed climate.	Care homes / School and childcare /	2

<ul style="list-style-type: none"> Outdoor environment and indoor air 		Municipality	
<ul style="list-style-type: none"> Human Health Outdoor environment and indoor air 	Inform and train management functions and personnel within care homes and school regarding health effects in a changing climate.	Care homes / School and childcare	2
<ul style="list-style-type: none"> Water ponds 	Inform dam owners about liability for damage to their own and someone else's property.	Technical Committee	2
<ul style="list-style-type: none"> Flooding of buildings 	Inform property owners who are in danger of flooding.	Technical Committee	2
<ul style="list-style-type: none"> Tourism and outdoor activities 	Investigate the possibilities of increased summer tourism.	Municipality	2
<ul style="list-style-type: none"> Building construction 	Inventory buildings with risk structures (Moisture / mold).	Corporate boards	2
<ul style="list-style-type: none"> Roads 	Inventory status on roads, And elevation of bridges.	Technical Committee	2
<ul style="list-style-type: none"> Drinking water 	Identify and secure possible backup water resources.	Technical Committee	2
<ul style="list-style-type: none"> Contamination spread 	Identify contamination risks in connection with drinking water sources (stormwater, wastewater, surface water).	Technical Committee / Environmental and health committee	2
<ul style="list-style-type: none"> Landslide and erosion 	Identify landslide risk areas.	Municipality	2
<ul style="list-style-type: none"> Water ponds 	Implement maintenance and reinforcement works.	Technical Committee	2
<ul style="list-style-type: none"> Water ponds 	Form a collaborative group for water management facilities.	Technical Committee	2
<ul style="list-style-type: none"> Building construction 	Establish guidelines for new basement construction.	Construction team	2
<ul style="list-style-type: none"> Drinking water 	Inform owners of individual water sources about the impact of climate change on water quality - deteriorated quality, increased pollution risk.	Environmental and health committee	3
<ul style="list-style-type: none"> Natural environment Woodlands 	Perform GIS analysis on land use And develop an inventory of adapted land use (i.e. recreation of wetlands, etc.).	Technical Committee Construction team	3
<ul style="list-style-type: none"> Woodlands 	Develop an improved monitoring of forest fires (Identify risks).	Federal emergency	3
<ul style="list-style-type: none"> Outdoor environment and indoor air quality 	Determine tree species in urban environment from one health and natural environment perspective.	Technical committee	3

Table 10 Växjö adaptation action plan. Source: Växjö commune, 2013a.

II.VI San Sebastian's Climate Adaptation Plan

1	High priority
2	Medium Priority

Actions	Addressed Impacts	Term	Priority
Coordinating with public agents the management of zones exposed to inundation.	Floods	Short	High
Periodically update the existing protocol of the services of flood emergency considering the effects of climate change.	Floods	Short	High
Regulate uses, activities and urban design criteria in exposed areas to flood.	Floods	Short/Medium	High
Establish a process of maintenance of the vulnerable infrastructure identified through flood maps.	Coastal Flood	Short/Medium	High
Improve knowledge of flood events (non-coastal) through modeling.	Floods	Short/Medium	High
Implement Urban Sustainable Drainage Systems (SUDs).	Pluvial Floods	Short/Medium	High
Assess the improvements to be incorporated into the sanitation network based on the network modeling results.	Pluvial Floods	Short/Medium	High
Study the impact of currents and sea level on the municipality's beaches and on tourism.	Coastal Flood	Medium	Medium
Developing studies to reducing the risk of dispersion of pollutants (in the event of flooding).	Floods	Medium	Medium
Awareness-raising campaigns to promote self-protection of property owners in areas exposed to flooding.	Floods	Medium	Medium
Assess the possibility of implementing natural solutions to minimize the threat of river and pluvial flooding.	Floods	Medium/Long	Medium
Review the existing protocol for the risk of fire in areas of interest for biodiversity.	UHI effect & heatwaves	Short	High
Prepare an UHI map of the city to find out critical points.	UHI effect & heatwaves	Short	High
Prepare a protocol for preventive action in the event of heat waves in collaboration with Osakidetza ⁶⁹ .	UHI effect & heatwaves	Short	High
Coordinate with experts the implementation of actions to prevent UHI effect.	UHI effect & heatwaves	Short	High
Collaborate in the collection of atmospheric data to demonstrate the effects of urban greening on ambient temperature.	UHI effect & heatwaves	Short	Medium
Assess the possible integration of green solutions within urban design criteria.	UHI effect & heatwaves	Short/Medium	Medium
Increase the permeability and vegetation in squares, public spaces and public edifices.	UHI effect & heatwaves	Medium	Medium
Encourage the greening of courtyards and patios in the neighborhoods "Centro" and "Gros".	UHI effect & heatwaves	Medium	Medium
Encourage greening rooftops and balconies of buildings.	UHI effect & heatwaves	Medium	Medium

⁶⁹ An institution established in the Basque country responsible for the public healthcare system.

Provide grants or subsidies to private owners in neighborhoods that are most sensitive to heat waves.	UHI effect & heatwaves	Medium	Medium
Carry out micro-scale thermal comfort studies that favor the design of comfortable urban spaces.	UHI effect & heatwaves	Medium	Medium
Examine the effect of increased temperature and heat waves on biodiversity.	UHI effect & heatwaves	Long	Medium
Limit urban sprawl to avoid the artificialization of the non-urban land.	All impacts	Short	High
Establish a permanent structure at the municipal level in charge of climate adaptation and urban resilience.	All impacts	Short	High
Generate relevant ad hoc indicators for decision-making in matters of climate adaptation.	All impacts	Medium	High
Obtain funding sources for the implementation of the measures contained in this Plan.	All impacts	Short/Medium	High
Increase knowledge on climate adaptation in different municipal departments.	All impacts	Medium	High
Assess the possibility of having the necessary human and material resources for the implementation of the adaptation plan.	All impacts	Medium	High
Promote knowledge and publicize the possible effects of climate change on the city.	All impacts	Short/Medium	Medium
Coordinate the measurement of climatic parameters and / or urban elements (sanitation networks).	All impacts	Long	Medium

Table 11 San Sebastian's Climate Change Adaptation Plan consisting of 31 actions. Data Extracted from: García et al., 2017.

Appendix III: Applying the Urban Climate Adaptation Governance index to the Case Studies

III.I Assessing the Urban Climate Adaptation Governance of the City of Rouen – Application of the developed index

	Questions	Yes/No	details	Score
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	A study on the exposure of Norman territory to the effects of climate change conducted by SGAR in 2013 at the request of DATAR.	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	No	There is no impact or vulnerability assessment done particularly for the city of Rouen. Impacts at the scale of the city are deduced from studies conducted at a regional level.	0
	Is there an identification of environmental consequences to climate change?	Yes	In the SGAR report, the SRCAE and the PCET. The impacts include Heatwaves and UHI effect, heavy storms and extreme weather conditions (i.e., flooding), droughts and reduced availability of water resources.	1
	Is there an identification of socio-economic repercussions?	±	Socio-economic impacts of climate change have been raised by SGAR and are addressed in the PCAET. The PCET however does not elaborate on the socio-economic ramifications.	0.5
	Have the sectors impacted by climate change been identified?	±	Sectors impacted by CC in the region have been identified by the SGAR however the PCET and the PCAET focus on the contribution of sectors to GHG emissions rather than the impact of CC on sectors.	0.5
	Is there an identification/mapping of vulnerable areas?	+/-	It has been established by the SGAR that the city center of the city is more sensitive to the UHI effect. The PPRI also identifies areas at risk of inundation. However, maps are developed at a regional scale and the scale of the metropolitan area rather than at the scale of Rouen. This undermines the ability of defining areas of the city that are vulnerable to climate change.	0.5
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the	±	The general public is showing more interest in environmental matters. However, the awareness of the citizens is still insufficient with regards to the gravity of the impacts and their consequences on their daily lives.	0.5

		participation of people in these events)		
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	The Grenelle II law requiring the development of PCET and SRCAE followed by the law relating to the energy transition for green grown requiring communities with more than 20,000 inhabitants to develop a PCAET.	1
	Is there a developed regional adaptation strategy?	No	The regional plan highlighted that it does not set quantitative targets to adaptation but recommends the region of Upper Normandy to develop of a regional adaptation strategy.	0
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	±	Elected officials are becoming more sensitive to environmental matters, however many at the heart of the municipality still lack the awareness or are not pushing for an environmental agenda. Also, more focus is given to mitigation actions.	0.5
	Is there a developed local adaptation strategy?	±	The PCET and the PCAET present territorial plans for environmental transition and include adaptation strategies but are rather focused on GHG emissions and air quality.	0.5
	Is the developed strategy “tailored” in response to assessed impacts and vulnerabilities?	Yes	Various commitments are made by the Métropole Rouen Normandy and the city of Rouen, to adapt the territory in response to assessed impacts.	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	±	The city’s agenda 21 prioritizes various areas of actions. However, most areas considered as top priority are rather focused on energy management.	0.5
	Does the adaptation strategy include medium term plans (Horizon 2030)	No	The strategy is more focused on short term actions. Medium-term actions are rather “timid” and focused on mitigation (e.g., PCAET ambition to renovation 45,000 unit by 2030) as a measure to assure energy transition (Métropole Rouen Normandie, ADEME & WWF, 2018).	0
	Does the adaptation strategy include long term plans? (Horizon 2050)	No	Both the city and the metropolis didn’t develop or clearly define long-term adaptation plans.	0
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	The city’s agenda 21 was set in collaboration with an external cabinet bringing together various actors of different competencies.	1

		The metropolis established a local IPCC to strengthen its knowledge and use it as a basis for the development of environmental policies.	
Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	±	Urban planners aren't particularly solicited for the development of adaptation strategies. However, the local IPCC includes urbanists and architects. Also, the local inter-communal urban plan (PLUi) needs to consider the objectives and strategies defined by the PCAET.	0.5
Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	±	The private sector is involved through signing the accord of Rouen which defines their engagements towards the environment. Nonetheless, this engagement is primarily focused on limiting GHG emissions.	0.5
Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	±	The local community enriched the strategy goals and challenges and the framework for the local Agenda 21 through the 'Rouennais Council of Sustainable Development' and online platforms. However, there is still no real participatory governance.	0.5
Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	±	The city of Rouen attached the sustainable development responsibility to the general direction of the political service to ensure a transversal approach. However, climate adaptation is not necessarily mainstreamed across various sectors and many actors still work in silos.	0.5
Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	±	In the PCAET developed at the scale of both the city of Rouen and the metropolis, for each adaptation action to be undertaken, the leader of the action and the identified partners which are responsible for implementing and following up on this action are identified. However, various actors do not know their role in addressing the issue of climate change.	0.5
Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked	No	While meeting with local key actors they have highlighted that departments still work in silo and there is a lack of coordination between city officials and officials at the scale of the metropolis and	0

	to assure the coordination between various actors)		across actors in different departments.	
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	The city of Rouen is a signatory city in the covenant of mayor initiative. Moreover, the city of Rouen is a member of the AIVP network of port cities.	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	±	The city's Agenda 21 and PCET highlights implemented actions as well as actions to be completed by a set deadline (I.e., establishing a group of independent experts on climate change adaptation issues, increasing the share of greenery). However, due to the lack of resources there has been delays in the implementation of many short-term measures.	0.5
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	No	While meeting with local key actors they have highlighted that the lack of adequate equipment and technical resources is a barrier to improve the understanding of impacts of CC and implement some adaptation initiatives.	0
	Are financial resources made available for the implementation of adaptation strategies?	±	Several European, national, and regional funding schemes already exist, and the city is developing new financing opportunities (i.e., crowd funding initiative). However, there's a need to an easier access to these aids. Financing adaptation projects and measures remains a barrier to implementation.	0.5
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience, and know-how necessary to carry out the implementation of adaptation measures)?	No	The lack of human resources constitutes a barrier to the development and implementation of adaptation strategies at both the scale of the city and the scale of the metropolis.	0
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±	Some initiatives such as the crowd funding project ("Je participe") allows the local community to support projects led by other citizens, associations and groups or scholars. However local actors highlighted that there is still room	0.5

			for improvement as there is still not real participatory governance.	
Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes		Local authorities communicate on the measures they have implemented, and citizens are informed of the decisions that are taken at a local scale.	1
Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes		I.e., The First prize in the category "Facilities, infrastructures and buildings" during the Climate Adaptation & Territories 2014 Award and the "Best Intercommunality for Biodiversity" prize for 2018.	1
Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	±		The rehabilitation of the Seine wharves in Rouen project was implemented to create an eight kilometers long public park along the seine river. While this big-scale project was not conceived with adaptation in mind, it still acts as a buffer zone in the events of river floods (Municipality of Rouen employee at the directorate of attractiveness and living environment , interview, 2019). Otherwise, no big scale project was implemented to protect the city from climate impacts.	0.5
Are green adaptation approaches implemented?	Yes		I.e. Pocket parks projects, the presqu'île rollet park, "Éco-vallée des deux rivières" and the "Jardin partagé de la Lombardie" as well as other projects in place to increase the share of greeneries. Also, the city is ensuring a better management of green spaces through planting vegetation requiring less watering.	1
Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	±		The city is implementing procedures to assist vulnerable people and warning system. Also, various tools are put in place by the metropolis to raise awareness about the issue of CC. However local actors highlighted that more effort should be put in this field.	0.5

	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves and drought)?	±	Some initiatives proved to have increased the city's adaptability. For example, the 'Plan Canicule' proved to be efficient as its implementation during the heat wave of summer 2006 helped reduce excess mortality. However, the city is still exposed and negatively impacted by floods, heatwaves, and other extreme environmental events.	0.5
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	The Cit'ergie label serves as a M&E tool for the city and the metropolis of Rouen. Also, both have their own proper indicators. The Cit'ergie label and the indicators are however more focused on emissions and air pollution rather than adaptation.	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	Every year, the committed city or community receives an annual visit from its advisor Cit'ergie who follows the progress of the implementation of its climate-air-energy action program. And every four years, the label awarded to a community is reconsidered based on a re-assessment.	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	A Cit'ergie councilor is commissioned by the community to accompany it in the animation of the Cit'ergie approach. Moreover, the advisor evaluates yearly the potential of points in the community and supports it in the implementation and the improvement of the PCAET.	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	To assure this monitoring, the city collects data from different city departments and relies on information and statistics developed by various regional and national institutes such as the INSEE, ATMO and ADEME.	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	In the context of Cit'ergie. I.e. the amount of water used for watering green spaces and the budget dedicated for the development of the PCAET.	1
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	In the context of Cit'ergie. I.e., Compactness of urban forms.	1
	Are M&E reported and communicated with targeted	Yes	Various reports were published assessing GHG emissions, air quality	1

Understanding Success and Limiting Factors	groups to inform practice and policy?		and actions undertaken by the metropolis. Also, the results of the Cit'ergie assessment are available online on the initiative's platform.	
	Are opportunities and levers to the implementation of adaptation identified?	±	Various actors consider different elements as levers to the implementation of adaptation. However, there is no clear identification of levers and opportunities as adaptation measures are still at an experimental level.	0.5
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	Local actors are aware of the barriers to the implementation of adaptation policies and measures. (e.g., the lack of financial, technical, and human resources).	1
	Is the local government supporting project studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	±	The city of Rouen is not actively supporting project studies conducted to improve the understanding of impacts at a local scale. However, a local IPCC was established by the metropolitan area of Rouen to conduct studies and develop an understanding of CC and its consequences at a local level, in order to develop appropriate adaptation solutions.	0.5
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	±	Various assessment of impacts of climate change have been published over the years however those updates are not consistent and are not made by the same body to integrate new findings.	0.5
	Are existing adaptation policies periodically updated?	±	The city published its PCET in 2013 as a 'continuity' of its agenda 21 "My city is my planet" released in 2011. In 2017 the City of Rouen undertook a second action plan for its agenda 21 to address the challenges raised by the first action plan, to raise new challenges and to reinstate its commitment to the ecological transition. However, to date the city hasn't elaborated a climate adaptation plan in the framework of its commitment to the Mayors' adapt initiative as it was aiming to.	0.5
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	±	The SGAR report (2013) presented climate projections on the horizons 2030, 2050 and 2080. However local actors highlighted that there is still a high uncertainty related to the	0.5

			understanding of impacts at a local scale on the long run making it challenging to adopt appropriate measures.	
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding	No	The adaptation policies are updated based on constitutional changes and new laws rather than an analytical review of the action or a recent impact assessment.	0
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	No	The short-termism is limiting the ability of authorities to consider the development of adaptation policies based on an adaptation pathway concept.	0
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	The city developed a PCS to increase its resilience and its preparedness to various events of emergency including natural risks.	1
Total				29/5 = 5.8
	$\alpha = \frac{\sum_{i=1}^{50} p}{5}$			

Table 12 Urban Climate Adaptation Governance index of the city of Rouen.

III.II Assessing the Urban Climate Adaptation Governance of the City of Nijmegen – Application of the developed index

	Questions	Yes/No	details	Score
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	The NAS helped the province to build an understanding of the impacts of CC on the region. The province is developing stress tests and is working on identifying vulnerabilities and opportunities. Data could be found on Gelders Platform for Spatial Adaptation.	1
	Is there a local impact assessment particular to medium sized cities (50,000-250,000)?	Yes	Studies, reports, and maps are developed at a local scale to understand the vulnerability of the city to droughts, floods and extreme heats.	1
	Is there an identification of environmental consequences to climate change?	Yes	The city is mostly vulnerable to floods due to raise of water levels and heavy rainfalls and is also exposed to heatwaves and is becoming more vulnerable to droughts.	1
	Is there an identification of socio-economic repercussions?	Yes	Delta scenarios highlights the risks of the growing dependence of businesses and citizens on ICT, electricity and transport could make societies more vulnerable to disruptions in the light of climate	1

			change and affect their daily lives are these services are becoming more interwoven.	
	Have the sectors impacted by climate change been identified?	Yes	The sectors that are vulnerable to the impacts of climate change in the city of Nijmegen have been defined and include urban planning and construction, energy, health, biodiversity, transport, and water management (EEA, n.d.).	1
	Is there an identification/mapping of vulnerable areas?	Yes	The old areas of the city of Nijmegen (i.e., the city center) are particularly vulnerable as they are densely built-up and paved over with little vegetation. Moreover, the eastern and southern parts of the city are likely to be affected by the rise of groundwater levels.	1
	Is the public informed of the impacts of climate change on the city? (e.g., availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	The EGC2018 showed a strong involvement of local citizens and contributed to improving local climate awareness.	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	The Delta Decision on Spatial Adaptation requires local governments to take action to increase resilience and reduce the impacts of CC.	1
	Is there a developed regional adaptation strategy?	Yes	The RAS addresses climate adaptation via various tracks and includes climate adaptation in the elaboration of the core tasks of the province's programs.	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	Local authorities and political actors are aware of the need to protect the city against floods, extended heatwaves, and droughts. The city has a stable political climate, and the mayor and vice mayor are behind the city's environmental and sustainable ambition.	1
	Is there a developed local adaptation strategy?	±	The city does not have a proper adaptation plan yet. The city's adaptation policy is encompassed in the present policy plans (on greenery, water, and sewage system) which protects its vulnerability to heat stress and	0.5

			heavy rainfall. The city aims at developing its proper adaptation plan by the end of 2021.	
	Is the developed strategy “tailored” in response to assessed impacts and vulnerabilities?	Yes	Various measures are implemented addressing the issue of rain and river floods, extreme temperatures and UHI as well as droughts.	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	Addressing the issue of flooding and water management is considered a priority as it is the most prominent issue. Less attention is given to addressing the issue of drought and UHI Effect.	1
	Does the adaptation strategy include medium term plans (Horizon 2030)	±	Short- and medium-term targets have been investigated by the delta program. The RAS also has the ambition of adapting the region to climate change by 2035 and no later than 2050. However, no clear mid-term plans, or targets have been presented by the city of Nijmegen.	0.5
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	The city of Nijmegen has the ambition to be climate proof by 2050 to protect itself against drought, heat and flooding.	1
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	Many experts at the university of Radboud have been involved in research on Nijmegen and the region; and part of this research is funded by regional or local authorities.	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	In the Netherlands the Delta Plan focuses on spatial adaptation. In Nijmegen, the Room for the Waal plan focused on architectural and spatial quality through providing multifunctional spaces and building with nature. Also, the planning and construction of new districts are based on the ecopolis approach (i.e., new neighborhood and construction project at the north of the river).	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	±	The city collaborates with institutes and businesses in the areas of energy neutrality and sustainable economy. This collaboration is not clear in climate adaptation.	0.5
	Is the local community (i.e. cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	Yes	The Government style in NL is based on collaboration. A participatory culture is dominant. In Nijmegen citizens are involved in spatial adaptation decisions	1

			through workshops, awareness campaigns and personal initiatives.	
	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	The city hasn't drawn an isolated climate adaptation strategy but is incorporating adaptive strategies to existing policy.	1
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	No	A study on the involvement of various stakeholders (Bernhard, et al., 2018) has shown that the division of responsibilities and tasks is rather unclear as no agreement or document of any kind defines the exact responsibility of each actor.	0
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	Yes	An employee at the province of Gelderland is tasked to assure the coordination between various actors within the province and between the province and the municipality of Nijmegen, among others. The coordination of efforts and the engagement of various stakeholders including waterboards, municipalities, provinces and national the national government is one of the city's success factors in addressing environmental concerns (EEA, 2014).	1
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e., ICLEI; Eurocities etc.)?	Yes	The city is participating with "European Interreg IVB Future Cities" project and is an ICLEI member since April 2015.	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	Various adaptation measures have been implemented in Nijmegen e.g., separating rainwater from sewage system, 190 000 paving stones were replaced by trees of plants and more than 10,000 trees were planted.	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	The Dutch city of Nijmegen has developed engineering technologies in the field of water management. Yet, one of the challenges that the city faces is the availability of material resources, such as lands, to implement adaptation projects.	0.5
	Are financial resources made available for the	±	In NL, A budget of € 2.5 billion covering the period 2009-2020 has	0.5

implementation of adaptation strategies?		been allocated, but it is considered insufficient to cover needs (Caude, et al., 2015). The city has the budget for the implementation of water management project but lacks the budget to develop new green areas.	
Are human resources made available for the implementation of adaptation strategies (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	±	The city of Nijmegen has a network of concerned actors and people with necessary expertise for the development and implementation of projects. However, in comparison to bigger cities like Rotterdam or Amsterdam, Nijmegen finds itself with a small team of experts at the heart of the municipality.	0.5
Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	Yes	Citizens are involved in the implementation of various initiatives. I.e., 'Operatie Steenbreek' project aims at engaging the citizens and encouraging them to replace the pavements and bricks of their properties by garden and plants.	1
Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	To increase its transparency, the city tries to involve the public as much as possible and the municipality is publishing budgets in a regular and transparent way on the website. Additionally, citizens are informed in the choices that are being taken by the municipality and can participate in the decision-making process.	1
Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	The city of Nijmegen received the "Green Capital" award for the year 2018, bestowed to reward the city's clear, driven, and convincing vision according to the judges.	1
Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	The room for the Waal project represents a big scale a spatial adaptation project protecting the city from river flooding.	1
Are green adaptation approaches implemented?	±	The local government is aware of the importance of greening the city and is inciting it through developing small-scale initiatives and providing subsidies. However, an adaptation policy advisor at the municipality of Nijmegen (2020) explained that the	0.5

			city lacks the budget for the development of green infrastructure systems. The budget that the city is for the management and maintenance of existing spaces rather than developing new areas.	
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	Yes	The city of Nijmegen is providing subsidies for green facades, green roofs, rain-water barrels, and for the separation of rainwater from sewage system.	1
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves and drought)?	±	The city is increasingly becoming more climate proof and has drastically increased its resilience to river floods. However, it needs to invest more to increase its resilience to heatwaves and the UHI effect.	0.5
Monitoring and Evaluation	Is there a M&E of adaptation at a local or regional level?	±	The city of Nijmegen has a “city and neighborhood monitor” focusing on attractivity, social aspect, economic resilience and sustainability but is not particular to adaptation.	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	The city and neighborhood monitor provides an image of the state as well as the development of neighborhoods and the city on a yearly basis.	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	The office for research and statistics works on monitoring and evaluation within the city of Nijmegen.	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	The city relies mainly on local data collected by the office of research and statistics for monitoring and evaluation. Residents are asked to provide their comments on various themes, including sustainability related topics. The city also takes benefits from data available at a regional and national level, as well as data provided by research institutes.	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	E.g., kilometers of flood defense, number of trees that have been planted and of stones that have been removed.	1
	Are there qualitative indicators to measure the implementation of	Yes	E.g., the satisfaction of local citizens with green areas (environmental quality).	1

	adaptation policies at a local level?			
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	The data from the “city and neighborhood monitor” is reported and communicated on an online platform (https://swm.nijmegen.nl) allowing an open public accessibility to monitored data in various themes.	1
	Are opportunities and levers to the implementation of adaptation identified?	Yes	E.g., the application for the EGC2018 was an opportunity by itself, as it increased the efforts to involve everyone. The coordination of efforts and the involvement of local community is considered a great success factor.	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	E.g., the implementation of the room for the Waal project, limiting factors included the expropriation of land, the development of compensation scheme and limited budget. Other challenges include reaching out to the people that are not directly spurred by sustainability.	1
	Is the local government supporting projects studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	Regional or local authorities are funding research on the region and Nijmegen at the Radboud university.	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	±	Through the implementation of various projects, the city is gaining insights and improving its understanding of environmental and climate issues. However, there are no newly published vulnerability or climate impact assessment.	0.5
	Are existing adaptation policies periodically updated?	±	The city’s adaptation policy is encompassed in the present policy plans (on greenery, water, and sewage system) which protects its vulnerability to heat stress and heavy rainfall. Nonetheless, the city aims at developing its proper adaptation plan by end of 2021.	0.5
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	The KNMI developed four climate scenarios for the country. All of these scenarios show that by 2050 the country will face significantly wetter and less cold winters. In Nijmegen, local actors are aware	1

			that climate change will increase the frequency and intensity of weather extremes and the risk of natural hazards.	
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	±	Amendments have been made to the environmental act and to the water act to give more room for flexibility and improve coordination. More money is made available to ensure the implementation of adaptation measures. However, no new recent vulnerability assessments have been developed yet.	0.5
	Are long term adaptation policies developed based on an adaptation pathway concept? (flexibility of long-term adaptation approaches)	Yes	The delta program ensures that the monitoring is done on an annual and a six-yearly basis to keep a balance between a quick response and flexibility on one hand, and coherence in choice and sufficient stability on the other hand. Nijmegen is experimenting and scaling up initiatives that proved to be successful (e.g., operatie steenbreek).	1
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	The city has a strong anticipation policy and local actors believe that the city has the capacity to deal with and overcome unexpected extreme weather events.	1
Total				43/5= 8.6
$\alpha = \frac{\sum_{i=1}^{50} p}{5}$				

Table 13 Urban Climate Adaptation Governance index of Nijmegen.

III.III Assessing the Urban Climate Adaptation Governance of the City of Leuven – Application of the developed index

	Questions	Yes/No	details	Score
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	The Flemish climate policy plan and the 'MIRA Climate report 2015' introduce the impacts of CC on the Flemish region. Impacts of climate change are also communicated to the public and available online on the Flemish Climate portal.	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	±	The scientific report (Vandevyvere et al., 2013) presented by KU Leuven in 2013 focuses on GHG emissions rather than impacts of climate change, nonetheless, Leuven 2030 communicates impacts of CC on the city and works closely with the	0.5

			university to produce knowledge at a local scale.	
	Is there an identification of environmental consequences to climate change?	Yes	Identification of environmental consequences include: UHI effect and heatwaves, flooding and extreme weather conditions and reduced availability of water.	1
	Is there an identification of socio-economic repercussions?	±	The identification of socio-economic repercussions is at a regional level and is not really elaborated at the scale of the city.	0.5
	Have the sectors impacted by climate change been identified?	±	The country's 7 th national communication report presents the projected impacts and their degree of gravity on various sectors. Also, the MIRA report sheds light on the sectors that will be impacted by CC. At the scale of the city, the sectors with high CO2 emissions, impacting climate change are identified, however, there is no clear or direct identification of sectors impacted by this global issue.	0.5
	Is there an identification/mapping of vulnerable areas?	Yes	A mapping of impacts has been conducted at the scale of the Flemish region and is publicly available in the form of an interactive maps available on the region's climate portal developed by the VMM. Additionally, as the city has experienced a series of flood throughout years, the area that is likely to be submerged is identified.	1
	Is the public informed of the impacts of climate change on the city? (e.g., availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	85% of the public in Belgium considers that CC needs to be addressed urgently. In Leuven more than 10,000 protestors hit the streets of the city on the 7 th of February 2019 demanding politicians to address climate issues and take appropriate measures which underlines the awareness and involvement of citizens.	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	The NAP declared that adaptation measures are to be developed and implemented by local and regional authorities.	1
	Is there a developed regional adaptation strategy?	Yes	The VAP (2013-2020) which is part of the VKP.	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for	Yes	The Mayor Mohamed Ridouani is convinced of the importance of ensuring the climate neutrality of the city and has stated that the city is collaborating with Leuven 2030 and wants to do even better. The green party has been in the	1

	environmental and climate action?)		municipal coalition since 2018 and is pushing for developing the environmental agenda and strengthening adaptation measures.	
	Is there a developed local adaptation strategy?	Yes	The city's climate action plan and the Leuven 2025 2035 2050 Roadmap include adaptation strategies and measures.	1
	Is the developed strategy "tailored" in response to assessed impacts and vulnerabilities?	Yes	The strategy is focused on addressing UHI effect, floods and drought through the development green and blue urban infrastructure.	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	±	Areas of priorities have been defined by both Flanders and Leuven; however, these priorities are mostly based on emissions rates.	0.5
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	The Leuven roadmap considers the horizon 2035.	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	The city has a long-term vision, and the Leuven roadmap considers the horizon 2050.	1
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	the VTFA responsible of the development of the VAP included experts in science and innovation. Also, the city of Leuven has made a collaboration deal with KU Leuven to guide the development of its policy actions.	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	'Leuven 2030' collaborated with BUUR, an urban-planning agency, as well as various experts to develop its roadmap 2025 2035 2050. The Vaartkom redevelopment is also an example of an urban spatial adaptation project.	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	Yes	Leuven 2030 and the municipality are working on implicating and involving the private sector in climate adaptation. The city is also working alongside companies that are located in the industrial zone to investigate how to include adaptation in that area through increasing the permeability of the ground.	1
	Is the local community (i.e. cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	Yes	'Leuven 2030' includes up to 500 citizens and members which are involved in the development of the roadmap 2025 2035 2050. Also, the city conducts public consultations in order to get feedbacks from citizens on proposed measures and initiatives.	1
	Are adaptation activities mainstreamed into various policy areas and included	Yes	Leuven embeds its climate neutral ambitions within the regular operation of various city services.	1

	within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?			
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	Yes	The city's climate action plan (2020-2025) defines the role of each department in addressing the issue of climate change.	1
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	±	The Autonomous Municipal Urban Development, financed by the city of Leuven, ensures project coordination and synergies across various sectors. The coordination between the city and the Flemish region is however weak.	0.5
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	The city is a signatory in the covenant of mayors and a member of Eurocities and CIVITAS allowing it to share knowledge and practices.	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	±	As adaptation is a "new" area of focus at the city scale, to date only a few projects have been implemented (e.g., water management approaches and increasing share of greenery) (Environmentalist and researcher at the KU Leuven, interview, 2021).	0.5
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	The local university is an asset to the city, providing it with knowledge and necessary technology, however the lack of availability of lands, due to the dense urban fabric, is in some cases a challenge for the implementation of projects.	0.5
	Are financial resources made available for the implementation of adaptation strategies?	±	The city has a budget for the implementation of plans ensuring the city's climate neutral objective, however the largest budget is mostly dedicating to energy policies. Also, assuring climate funds remains a challenge.	0.5
	Are human resources made available for the implementation of adaptation strategies (a multidisciplinary team that possesses the skills,	Yes	The city is working alongside KU Leuven and have hired professionals who have the necessary knowledge for the development and implementation of climate plans.	1

experience and know-how necessary to carry out the implementation of adaptation measures)?			
Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±	Some projects such as “kom op voor je wijk” and “100 trees for Leuven” ensure the participation of the local community in the implementation of adaptation measures. However, the alderman in the board of mayor at the city of Leuven (interview, 2020). elucidated that, despite efforts to engage people, it remains a challenge to involve and bring together all the different interest in the city.	0.5
Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	The city is ensuring transparency through communicating with the citizens the projects that it is developing and the multi-year budget once it is set.	1
Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	Nominated for “Most sustainable municipality in Belgium” in 2013 and received the EGLA in 2018.	1
Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	No	The city is developing various small-scale initiatives, yet it still has to develop projects on a bigger scale (Leuven municipal councilor representing the Green party, interview, 2020).	0
Are green adaptation approaches implemented?	Yes	The city is developing its green and blue infrastructure to increase its adaptability to climate change. E.g., the surface of green areas managed by the city increased from 200 hectares to 300 hectares in a decade and a half.	1
Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	Yes	The city is working in collaboration with schools and environmental organizations to develop awareness campaigns. It is also using financial and legal incentives to stir the implementation of adaptation approaches.	1
Did the implemented adaptation projects reduce the exposure of the city to climate risks (including	±	The city has been addressing the flooding of the Dijle for decades yet is aware that the engineered systems in place are not enough to protect the	0.5

			floods, heatwaves and drought)?	city from flooding, so other solutions are being investigated and developed.
Monitoring and Evaluation	Is there a M&E of adaptation at a local or regional level?	±	The city's climate plan (2020-2025) defines for each measure the indicators to monitor its implementation. However, both the province Flemish Brabant and the city of Leuven aim at developing a more thorough M&E system particular to climate adaptation.	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	In Flanders, sectorial pilots must report on the actions defined by the VAP on a 2-yearly basis. At the scale of Leuven, the roadmap asserts that, as of 2020, a survey will be conducted on a two-yearly basis to collect and update the required data.	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	The climate action plan (2020-2025) underlined that a 'core climate adaptation group' is responsible to monitor the progress of the adaptation policy plan and insure its horizontal integration across different city services.	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	±	The city makes statistical data including environmental indicators available on its website. However, the city's roadmap to climate neutrality asserted that there is a need for more environmental knowledge and data specific to Leuven to monitor and evaluate the results and to optimize measures for climate transition (e.g., no local data on water quality, water consumption and water losses in distribution network). More data is available at a supra-municipal and national level.	0.5
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	E.g., the number of projects implemented to increase the permeability of surfaces as well as quantity of recovered source water.	1
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	No	The climate adaptation plan does not embrace qualitative indicators.	0
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	±	At the scale of Flanders, progress reports on the Flemish climate policy are published. At the scale of the city, data and indicators are published and available online. However, the city of	0.5

			Leuven hasn't really developed a progress report.	
	Are opportunities and levers to the implementation of adaptation identified?	Yes	The city believes that the Leuven 2030 organization and the 2025 2035 2050 roadmap to climate neutrality present a great opportunity for increasing the resilience of the territory and adapting it to climate change.	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	Adaptation challenges and barriers impeding the implementation of adaptation have been identified at a regional, provincial, and local level. E.g., lack of financial resources, social climate justice.	1
	Is the local government supporting projects studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	The city and Leuven 2030 are working closely with the local university to close knowledge gaps and address challenges. They are constantly working on learning from experience and closing knowledge gaps.	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	No	The city hasn't developed a proper vulnerability or impact assessment introducing the impacts of climate change on the city.	0
	Are existing adaptation policies periodically updated?	Yes	A VAP (2021 – 2030) followed the development of a VAP (2013 – 2020). Also, the city's action plan is updated on a 5- or 6-years basis. The First action plan covered the period between 2013-2019. The second action plan was particular for the period 2020-2025.	1
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	±	The MIRA report presents climate projection over 30, 50 and 100 years based on 3 scenarios in terms of impact: Low, medium, and high. However, no environmental or a climate risk assessment based on projections was introduced at the scale of the city of Leuven.	0.5
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	±	A new VAP is to be developed building on measures and results from the previous VAP and not really based on a new vulnerability assessment. Also, the city introduced a new climate action plan (2020-2025) based on an assessment of the previous climate action plan (2013-2019) however this assessment was concise and did not elaborate on challenges and opportunities.	0.5
	Are long term adaptation policies developed based on an adaptation pathway	Yes	The roadmap draws a flexible trajectory and action plans are updated to meet long-term targets	1

concept? (Flexibility of long-term adaptation approaches)			
Are emergency plans developed to overcome risks or unexpected extreme environmental events?	±	As soon as a disaster occurs, the general system of emergency planning is triggered, either at the communal level, provincial or federal. However, no contingency or emergency plans have been developed at a local scale to respond to risks that are linked to climate change.	0.5
Total			39/5 =
$\alpha = \frac{\sum_1^{50} p}{5}$			7.8

Table 14 Urban Climate Adaptation Governance index of Leuven.

III.IV Assessing the Urban Climate Adaptation Governance of the City of Växjö – Application of the developed index

	Questions	Yes/No	details	Score
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	The SMHI developed a regional vulnerability evaluation of impacts of climate change. The results are reported in the 'Regional Climate and Vulnerability Analysis Kronoberg County – Risk for floods and high flows' report in 2010.	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	Yes	The city of Växjö used the regional climate analysis report as a basis for developing a risk and vulnerability assessment (RSA).	1
	Is there an identification of environmental consequences to climate change?	Yes	The Växjö adaptation plan highlighted that the increase in average temperatures would lead to milder winters, the decrease in number of days with snow cover, change in rainfall patterns, an increase in the intensity and frequency of heavy rainfall events etc.	1
	Is there an identification of socio-economic repercussions?	Yes	The municipality have identified the repercussions of CC on 4 systems: (1) human health, (2) constructions and buildings, (3) technical supply systems and infrastructure, (4) natural environment, agriculture, and tourism.	1
	Have the sectors impacted by climate change been identified?	Yes	The regional adaptation plan introduced the impacts of climate change on various sectors including governance, community planning, water, human health, agriculture, natural environment, and cultural heritage. Also, in the city of Vaxjo the	1

	Is there an identification/mapping of vulnerable areas?	Yes	sectors that are impacted by climate change have been identified. A GIS layer has been developed in Västra mark, Norremark, and Växjö's city center showing the amount of mineralized surface area per property. The data allows to identify vulnerable areas from an urban heating perspective and the areas that could suffer from major problems with stormwater in the event of heavy rainfalls (Växjö commune, 2013a).	1
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	The city organizes regular information meetings and surveys have shown that the participation and awareness of citizens is relatively high and is progressively increasing over the years.	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	In Sweden, the responsibility to adapt and to develop action plans have been delegated to regional authorities. The implementation responsibility is however passed on to municipality levels.	1
	Is there a developed regional adaptation strategy?	Yes	Kronoberg County published its action plan for climate adaptation in March 2016 serving as a guideline for municipalities and regional actors.	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	The politicians and key local actors at the municipality of Växjö are aware of the importance of adapting to climate change and politicians have unanimously agreed on the importance of addressing environmental matters.	1
	Is there a developed local adaptation strategy?	Yes	In 2013, the municipality of Växjö developed its climate adaptation plan.	1
	Is the developed strategy "tailored" in response to assessed impacts and vulnerabilities?	Yes	The adaptation plan proposes possible measures to address the issue of floods, water availability, increase of temperatures and the UHI effect, the vulnerability of the electricity system, impacts on human health and measures ensure the resilience of the built environment to climate change.	1

	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	The adaptation plan organizes the measures to be taken based on 3 levels of priority. The most urgent measures are the ones to address existing major problems where work or improvements are needed immediately.	1
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	In 2019, the city of Växjö presented its climate sustainability agenda 2030 and declared its commitment to take local and global responsibility for the environment, people and the economy and invite different actors to contribute to this vision (Växjö commune, 2019).	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	±	Växjö has developed a 2050 long term vision, however, this vision focuses on assuring climate neutrality and does not elaborate on adaptation.	0.5
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	±	The municipality of cooperated with consultants as well as experts from the academic world for the development of Bäckaslöv. Also, the municipality works closely with the Linnaeus university and makes sure to take into consideration the knowledge developed by experts in the definition of its action plan. However, the collaboration with the university is mainly focused on sustainable construction and energy management rather than climate adaptation.	0.5
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	A project group established to develop the adaptation plan in the city included representative from the planning office. In 2011, the Swedish planning and building act introduced that climate aspects and risks should also be considered in the planning.	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	No	An environmental strategist at Växjö municipality (interview, 2020) asserted that in adaptation, the contribution of the private sector is still at its early stages. Private actors were invited to participate and in various environmental dialogues with the municipality through roundtable debates and public meetings but are in directly involved in the development of adaptation strategies	0

Is the local community (i.e. cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	Yes	In 1995, the municipality collaborated with the biggest environmental NGO in Sweden (SSNC) to guide its environmental actions. The Växjö commune (2021) presented in a communication on its online platform that approximately 2,000 residents, organizations and companies have participated in dialogues about Växjö municipality's future to update the municipality's general sustainability plan.	1
Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	The parties that are responsible for the implementation of the climate adaptation measures include the technical committee, environmental and health committee, schools and childcare, corporate boards, workers and developers in the construction field, workers in the tourism industry, the federal emergency unit, the municipality among others.	1
Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	±	The Växjö adaptation plan underlines for each measures the party that is responsible for implementing it. However, in practice some actors still don't know how to act on adaptation.	0.5
Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors).	±	In an interview, an employee at the municipality of Växjö explained that there is no person responsible for assuring the coordination of adaptation efforts among various actors once the definition of the action plan is done. The coordination is limited to the development of the adaptation plan.	0.5
Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e., ICLEI; Eurocities etc.)?	Yes	The city of Växjö is involved in national and international city networks allowing for the exchange of knowledge and expertise such as Klimatkommunerna, ICLEI, Union of the Baltic Cities and Energy Cities. The municipality of Växjö has also signed the covenant of mayors and paired with the city of Burlington through the International Urban Cooperation program (IUC) to collaborate on the development of an ecosystem approach to urban planning.	1

Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	e.g., retention ponds for surface runoff have been constructed both under and over the ground in the city to avoid the flooding of cellars and houses.	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	A member of the Växjö climate commission (interview, 2020) highlighted that the municipality can take measures in the buildings that it owns (i.e., some elderly care centers and school buildings). However, it cannot take actions in buildings and lands that it does not own.	0.5
	Are financial resources made available for the implementation of adaptation strategies?	Yes	Local municipalities raise taxes and manage the budget and public spending from pensions to educations. Also, Local governments can apply for investment funds awarded by the Swedish government for environmental protection.	1
	Are human resources made available for the implementation of adaptation strategies (a multidisciplinary team that possesses the skills, experience, and know-how necessary to carry out the implementation of adaptation measures)?	Yes	Public servants from various departments are responsible to ensure the implementation of adaptation projects (Environmental strategist at Växjö municipality, interview, 2020).	1
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	Yes	The city of Växjö is encouraging its citizens to change their habits and take part in the implementation of adaptation measures through awareness raising campaigns and the development of financial incentives and disincentives. E.g., in 2007, in celebration of the World Environmental Day, the citizens of Växjö were incited to make environmental commitments.	1
	Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	The municipality is ensuring transparency through public dialogue and discussions as well as monitoring and evaluation. The city established a great level of credibility due to its strong political commitment and the ability to present quantifiable and concrete results. This facilitated the obtention of funds from the national government and the EU for various projects (Cappelletti et al., 2015).	1

	Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	In 2007, the city won the 'Sustainable Energy Europe Award'. It also received the European Green Leaf Award in 2018 for its efforts in addressing important environmental issues.	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	The construction of the Linnaeus canal has allowed to protect the city from floods and is expected to protect, at least in part, the city from future floods.	1
	Are green adaptation approaches implemented?	Yes	Växjö is promoting itself as 'the greenest city in Europe', has developed a green strategy and implemented various greening projects (e.g., urban agriculture initiatives, the Västra Mark and the Bäckaslöv neighborhoods).	1
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives, or disincentives (i.e., taxes or subsidies)?	Yes	Environmental issues have been included in the curriculum of secondary schools to influence the behavior of the younger generation. The municipality also has various financial incentives and disincentives to	1
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?	Yes	Various environmental projects have benefited the city. For instance, the Linnaeus canal project proved to be a success as after its construction, floods did not occur with the same frequency and severity.	1
Monitoring and Evaluation	Is there a M&E of adaptation at a local or regional level?	±	The ecobudget, presents an interesting tool used by the city to monitor and evaluate its environmental and ecological transition, however it is not very much inclusive of indices allowing to monitor and assess adaptation actions. The municipality is currently working on developing indicators to monitor its progress on sustainability, but these indicators are not directly focused on adaptation.	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	The regional action plan for climate adaptation is to be revised and updated on a 5-yearly basis, with improved and more specific sub-goals based on M&E. In Växjö, each administration has the responsibility to report directly to the municipality's environmental coordinator on a yearly basis.	1

			Not to mention, the city's ecological and economic budgets define key indices that are assessed twice a year using the Ecobudget tool.	
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	The municipality's environmental coordinator is responsible to assure monitoring and evaluation at a local level.	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	The municipality collects and complies data from various sources to ensure monitoring, evaluation and reporting including national and regional levels, statistic agency and key local actors such as the local energy company.	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	No	The city has various quantitative indicators; however, these are not particular to monitor adaptation, and are more focused on mitigation and sustainability progress.	0
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	Monitoring of adaptation is more of qualitative nature, i.e., what kind of measures are implemented to increase the city's resilience to climate change, what are the actions have been carried out and the status of these actions.	1
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	National and regional governments are required to report their adaptation efforts on a yearly basis. Data is reported to the platforms but only part of it is made publicly available. The municipality develops a report on a yearly basis or two-yearly basis for the covenant of mayors and the impact of mayors to track the progress on both mitigation and adaptation efforts.	1
	Are opportunities and levers to the implementation of adaptation identified?	Yes	Van Staden & Musco (2010), and Cappelletti et al. (2015) determined success factors to climate adaptation and ecological transition.	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	The implementation of some measures allowed to determine challenges e.g., strengthening the capacity of existing and built structure to climate impacts and influencing residents to alter their behavior, especially when that entails changes in their lifestyle or financial sacrifices.	1
	Is the local government supporting projects studies	Yes	The city develops yearly risk reports (Environmental strategist at Växjö	1

	conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?		municipality, interview, 2020) and is continuously developing its knowledge when it comes to climate and environmental protection.	
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	Yes	A new risk and vulnerability analysis is developed integrating new findings.	1
	Are existing adaptation policies periodically updated?	Yes	A new adaptation plan was published in 2021.	1
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	E.g. the existing stormwater management systems need to be upgraded as predictions foresee that precipitation could increase by 15 to 20% by the end of the century (Växjö commune, 2013a).	1
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	Yes	The recently developed adaptation plan is based on knowledge acquired since the development and implementation of the 2013 adaptation plan.	1
	Are long term adaptation policies developed based on an adaptation pathway concept? (flexibility of long-term adaptation approaches)	Yes	The city is aiming on updating its adaptation strategy on a cyclical basis to ensure it is integrating new insights (Environmental strategist at Växjö municipality, interview, 2020). Växjö is also working closely with the 'Stockholm Resilience Center' that considers 7 aspects of resilience that need to be considered while designing a resilient city including flexible solutions.	1
	Are emergency plans developed allowing to overcome unexpected or unplanned for extreme environmental events?	Yes	Risk reports are produced on a yearly basis and "Värends Rescue Service" is a municipal association that cooperates with municipality members for crisis, fire, and risk management issues.	1
Total				45/5= 9
	$\alpha = \frac{\sum_{i=1}^{50} p}{5}$			

Table 15 Urban Climate Adaptation Governance index of Växjö.

III.V Assessing the Urban Climate Adaptation Governance of the City of San Sebastian – Application of the developed index

	Questions	Yes/No	details	Score
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	In 2010, research has been conducted to map the impacts of climate change in the Basque country. The following year,	1

		maps were developed identifying the likelihood of flooding, according to various climate change scenarios, due to the rise of sea level along the Basque coastline.	
Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	Yes	In 2015 a thorough diagnosis was carried out for the preparation of the municipality adaptation plan in San Sebastian.	1
Is there an identification of environmental consequences to climate change?	Yes	The impacts that were particularly considered at a local scale are the swell and the sea level rise, river floods, rain floods, heat waves and its impacts on health as well as the increase of temperatures and its impacts on biodiversity (Feliú, et al., 2017).	1
Is there an identification of socio-economic repercussions?	Yes	The basque government and the city of San Sebastian are aware that CC could have serious consequences on the economic, social, and environmental sphere including damages to infrastructures and houses, drops in productivity and loss of businesses as well as harm to health and human losses.	1
Have the sectors impacted by climate change been identified?	Yes	The adaptation plan introduces diagrams graphically representing cause-effect relationships of climate change variables and extremes events on various sectors including energy, tourism, water supply and demand, built environment, infrastructures, and public health (Feliú, et al., 2017).	1
Is there an identification/mapping of vulnerable areas?	Yes	I.e., The 'Centro' neighborhood, particularly the 'Área Romántica' is exposed to floods due to the rise of sea level as well as the risk of river flooding due to its proximity to river 'Urumea' (Gutiérrez, et al., 2017). This area is also at risk to urban heat island effect due to the high mineralization of the surface and the lack of vegetation.	1
Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications,	Yes	For 63.7% of the citizens of the basque country, climate change will affect the health of the population, such as allergic	1

	awareness campaigns, local environmental/climate events as well as the participation of people in these events)		processes (71.2%), skin cancer (68.7%) or respiratory problems (66.67%). The city of San Sebastian is working on communications and awareness campaigns to inform the public about these impacts, but it is still a work in progress.	
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	Regional governments had the responsibility to endorse environmental plans, to develop legislations related to their territorial scope and to carry out environmental procedures and grand corresponding permits In Spain, the 7/1985 law of April 2, gave the municipalities that have more than 50.000 inhabitants the responsibility and competencies in term of legislation in matters of environmental protection.	1
	Is there a developed regional adaptation strategy?	Yes	In 2015, the Basque government adopted a new climate change strategy “Estrategia de Cambio Climático 2050 del País Vasco” (Klima2050) aiming to reduce carbon dependency and minimize the region’s vulnerability to climate change by 2050.	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	Aware of the importance of local action, the municipality of Donostia / San Sebastian approved in 2008 its first Plan to Combat Climate Change (2008-2013), which already addressed the need for work on both mitigation and adaptation. In March 2020, the local government board approved the declaration of climate emergency in the city.	1
	Is there a developed local adaptation strategy?	Yes	San Sebastian in collaboration with the Basque Government published a climate change adaptation plan “Plan de Adaptación al Cambio Climático de Donostia/San Sebastian”. The plan was updated in 2020. The city also developed a 2050 climate strategy.	1
	Is the developed strategy “tailored” in response to	Yes	The plan includes general measures to increase the	1

	assessed impacts and vulnerabilities?		resilience of the city to climate change and actions to deal with UHI effect and heatwaves as well as pluvial, coastal, and fluvial floods.	
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	The adaptation plan presents 31 concrete actions and for each action the priority is defined (high, medium, or low) based on the level of urgency and the availability of budget.	1
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	The Basque country and the city of San Sebastian have developed 2030 milestones as part of their 2050 climate strategy. e.g., The city aims at increasing the green surface by 15% by 2030 (GEA21, 2018)	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	Both the Basque country and the city of San Sebastian developed a climate strategy 2050.	1
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	For the development of the Basque climate strategy various specialists were involved including researchers and scientists at the University of the Basque Country. In San Sebastian, the municipality is collaborating with consultancy and technology centers for the development of the adaptation plan.	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	The Technical Commission for Adaptation of Donostia / San Sebastian includes members from the departments of Town Planning and Maintenance and Urban Services. Its task is to participate in the development of the climate change adaptation strategy.	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	±	The city has periodic meetings with the biggest local company (cement factory). Also, when developing the local climate strategy 2050, the city met with the Gipuzkoa association of businessman to introduce them to the issue and ensure collaboration. However, this collaboration is more in climate mitigation rather than adaptation and many private actors do not know their role in	0.5

			addressing the issue of climate change.	
	Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	No	To date there is no formal procedure allowing for the participation of the public in the decision making or in the implementation of adaptation measures (San Sebastian Climate consultant 1, interview, 2021).	0
	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	In the Basque government, all ministries were involved in the development of the adaptation strategy to mainstream climate planning in various sectoral policies. In San Sebastian, the adaptation document is not a plan to develop a public policy, but a plan that backbones all public policies of the municipality (GEA21, 2018).	1
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	Yes	The adaptation plan presents 31 concrete actions and defines for each, the main actors responsible for implementing it.	1
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	Yes	The city collaborated with the Basque government for the development of its adaptation plan. A city's adaptation commission is responsible for supporting all departments to align their policies in order to achieve climate commitments and is ensuring coordination across various sectors.	1
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e., ICLEI; Eurocities etc.)?	Yes	the Basque Country joined the 'Compact of Regions' and San Sebastian committed itself to Mayors Adapt. Also, the city is a part of CIVITAS, an international network of cities working on developing sustainable urban transport.	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	Various projects are being implemented to develop knowledge at a local scale and adapt the city to CC, i.e.: The garden city of Loiola project; A submersible river park project (Parque fluvial Txominenea) and	1

			the widening of the Urumea river.	
Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	Yes		The city is working in proximity with technical and research centers assuring the necessary technical and technological resources for the implementation of various projects (i.e., SmartKalea, mapping systems etc.).	1
Are financial resources made available for the implementation of adaptation strategies?	±		The city's environment's expenditure is negligible as it represents approximately 2.9% of the city's total budget. The lack of financial resources is hindering or delaying the implementation of adaptation measures however, the city is actively seeking financing lines from the Basque country and European projects and initiatives	0.5
Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience, and know-how necessary to carry out the implementation of adaptation measures)?	±		The city has a competent team of technicians and employees working on environmental matters, but according to Environmentalist at the San Sebastian City Council, the city needs more staff. Hiring more people leads to additional expenses and costs and at the moment the city can't afford it.	0.5
Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±		The majority of projects are conducted by municipal actors. Very few projects are conceived in coordination with citizens such as the garden city of Loiola which was re-designed in 2014 through a process of citizens participation. 3 participatory workshops were organized to develop the proposal for the urban plan.	0.5
Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes		The city of San Sebastian presents its annual budget on its official website. The public has access to the city's financial plan from 2011 until the current year. This increases the city's transparency as it allows citizens to understand the sources of income as well as city's expenditure.	1

	Has a city received an award or a label for implementing an award worthy environmental initiative?	±	The SmartKalea initiative was recognized with the 'Smart Cities Award' for 2015 granted by SOFINCO Foundation. The city also received the 2017 CNIS (Congreso Nacional de Innovación y Servicios Públicos) award for the best public-private collaboration project. However, these awards are not particularly awarding worthy adaptation initiatives.	0.5
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	A submersible river park project (Parque fluvial Txominenea) and the widening of the Urumea river.	1
	Are green adaptation approaches implemented?	±	The city has various urban parks which existed for a while and are not particularly developed to ensure climate adaptation; however, they present themselves as nature-based solutions.	0.5
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives, or disincentives (i.e., taxes or subsidies)?	±	The city of San Sebastian developed warning systems as part of its emergency plan and aims to develop awareness-raising campaigns to promote self-protection of property owners in areas exposed to flooding. However, the work is at its embryotic stage and many public and private actors still do not know their role in addressing the issue of climate change.	0.5
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?	±	As implemented measures are at an embryotic stage, it is hard to determine if the various projects implemented at a local scale have directly reduced the exposure of the city to climate risks, however these projects have sure allowed to increase the city's adaptive capacity allowing to increase its resilience to climate events.	0.5
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	The Basque country committed itself to develop monitoring and assessment reports. At the scale of San Sebastian, the city is working on improving monitoring and evaluation. The SmartKalea initiative allows to	0.5

		monitor and develop indicators which help in the management of the city. However, the existent monitoring systems are more focused on emissions and sustainable development and are not particular to adaptation.	
Is the existing monitoring and evaluation continuous and periodic?	Yes	The Basque country is developing monitoring reports on a 2 yearly basis and interim assessment reports every 10 years. The city evaluates its local sustainable development policies at a yearly basis.	1
Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	At a regional scale (Basque Country) an external independent entity is set to prepare follow-up reports to assure transparency. At a local scale (San Sebastian) the technical commission of adaptation meets a couple of times per year to supervise what actions have been implemented, what measures need to be adjusted.	1
Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	±	The 200 municipalities that are part of the Udalsarea network must report the progress of their environmental policies. In San Sebastian, municipal departments are responsible to report on the progress of specific actions. The SmartKalea through its sensors offers data at a local scale, however this data is collected in 2 neighborhoods as the initiative hasn't been scaled up yet.	0.5
Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	No	The quantitative indicators are more relative to assess the evolution of weather events and its manifestation in the light of climate change and are not particular to assess the development of adaptation efforts.	0
Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	This evaluation is based on a qualitative analysis of degree of compliance or execution of the planned adaptation actions.	1
Are M&E reported and communicated with	Yes	The SmartKalea project makes the results of monitoring publicly	1

Understanding Barriers to Implementation	targeted groups to inform practice and policy?		available and accessible through the website ⁷⁰ , allowing for an informed decision making at the level of households, private corporations, and local governments. The city's updated climate adaptation plan published in 2020, sheds the light on the progress that has been made in the implementation of different actions since the development of the first action plan and defines the gaps or the areas that need to be addressed.	
	Are opportunities and levers to the implementation of adaptation identified?	Yes	Local actors believe that the city has a competent team of experts that is always open to participating in innovative projects and have the willingness to put the city on the map as a pioneer in addressing environmental issues. The city's technical commission has also played a crucial role in creating synergies, ensuring coordination between various departments as well as alignment between implemented measures and the city's long-term ambition.	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	Among the challenges at a local scale is the fact that the concept of climate change appears to be abstract and away from everyday life. Also there seems to be a contradiction between the times of climate change and the times of cultural change.	1
	Is the local government supporting projects studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	The city is continuously working on developing new knowledge in collaboration with research and technology centers to inform decision making.	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	No	A diagnostic was developed in 2017 and was not updated. The city has no plans to periodically updates its climate diagnosis based on an established frequency as it does not know how the knowledge will evolve.	0

⁷⁰ <http://www.fomentosansebastian.eus/smartkalea/en/monitoring>.

Are existing adaptation policies periodically updated?	Yes	The city developed a new adaptation plan in 2020 as an update of its 2017 adaptation plan and aims on continuously improving the adaptation policies in place based on acquired knowledge and experience.	1
Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	The city is aware of the long-term impacts of climate change. E.g., 2100 projections foresee a continuous increase in average temperature. The maximum temperature is expected to increase by 2.8 °C considering a worst-case scenario. Local actors are also aware that the rise of sea level will have serious consequences on the city if no adaptation measures are implemented.	1
Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	Yes	The city developed a new adaptation plan in 2020 building up on knowledge acquired since the development of the first adaptation plan in 2017.	1
Are long term adaptation policies developed based on an adaptation pathway concept? (flexibility of long term adaptation approaches)	Yes	Having a long-term strategy however assures the flexibility of short- and medium- term adaptation plans. The implementation and development of measures is reviewed and adjusted based on acquired knowledge (Environmentalist at the San Sebastian City Council, interview, 2021).	1
Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	The city of San Sebastian's developed a flood emergency plan and a municipal plan against forest fires in Igeldo. In its adaptation plan it emphasizes the importance of periodically updating the existing protocol of the services of flood emergency considering the effects of climate change.	1
Total			42/5 = 8.4
$\alpha = \frac{\sum_{i=1}^{50} p}{5}$			

Table 16 Urban Climate Adaptation Governance index of San Sebastian.

Appendix IV: Feedback loop – Urban Climate Adaptation Governance Index

IV.I Feedback loop-3rd party assessors

Questions	Details	Yes/No	A	Yes/No	ICS
Is there a national action plan requiring local or regional authorities to take climate actions?	The Grenelle II law requiring the development of the PCET and SRCAE followed by the law relating to the energy transition for green growth requiring communities with more than 20,000 inhabitants to develop a PCAET.	Yes	1	Yes	1
Is there a developed regional adaptation strategy?	The regional plan highlights that it doesn't set quantitative targets to adaptation but recommends the region of Upper Normandy to develop a regional adaptation strategy.	No	0	+/-	0.5
Are local authorities aware of the importance of adapting the territory to impacts of climate change?	Elected officials are becoming more sensitive to environmental matters, however more focus is given to mitigation actions.	+/-	0.5	+/-	0.5
Is there a developed local adaptation strategy?	The PCET and the PCAET present territorial plans for environmental transition and include adaptation strategies but are rather focused on GHG emissions and air quality.	+/-	0.5	+/-	0.5
Is the developed strategy "tailored" in response to assessed impacts and vulnerabilities?	Various commitments are made by the Metropole Rouen Normandy and the city of Rouen to adapt the territory in response to the assessed impacts	Yes	1	Yes	1
Is the strategy prioritizing actions increasing the territory's adaptability and resilience?	The city's agenda 21 prioritizes various areas of actions. However, most areas considered as top priority are rather focused on energy management.	+/-	0.5	+/-	0.5
Does the adaptation strategy include medium-term plans?	The strategy is focused on short term actions. For instance, in the city's first action plan covers the period 2011-2014, the second one covers the period 2017-2021. The metropolis action plan covers the period 2019-2024.	No	0	+/-	0.5
Does the adaptation strategy include long-term plans?	Both the city and the metropolis didn't develop long term adaptation plans with specific targets.	No	0	No	0

Table 17 Table comparing the researcher's (R) answers to the questions forming the urban climate adaptation governance index to the Imperial College Students (ICS) answers in the area of 'developing adaptation strategy'.

Questions	Details	Yes/No	A	Yes/No	ICS
Is there a M&E of adaptation at a local or regional level?	The Cit'ergie label serves as a M&E tool for the city and the metropolis of Rouen. Also both have their own indicators	Yes	1	Yes	1

Is M&E at a local or regional level required and formalized in legislation?	The Cit'ergie label is a voluntary commitment however it is required that the PCAET include indicators for monitoring and evaluation at the scale of the territory	+/-	0.5	+/-	0.5
Is there personnel or a committee dedicated for monitoring and assessment at a local level?	A Cit'ergie councilor is commissioned by the community to accompany it in the animation of the Cit'ergie approach. Moreover, the advisor evaluates yearly the potential of points in the community and supports it in the implementation and the improvement of the PCAET.	Yes	1	Yes	1
Are there financial resources dedicated for monitoring and assessment at a local level?	The ADEME offers financial support for the accompaniment of the community by a Cit'ergie councilor. However, the lack of financial resources could cause delays in regularly surveying the development and implementation of adaptation strategies.	+/-	0.5	No	0
Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	In the context of Cit'ergie. E.g., the amount of water used for watering green spaces and the budget dedicated for the development of the PCAET.	Yes	1	Yes	1
Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	In the context of Cit'ergie. E.g., Compactness of urban forms.	Yes	1	Yes	1

Table 18 Table comparing the author's (A) answers to the questions forming the urban climate adaptation governance index to the Imperial College Students (ICS) answers in the area of 'monitoring and evaluation'.

The charts above (*table 17 and 18*) show that there is no significant difference between the answers of the author and the answers of the Imperial College Students (presenting 3rd party independent assessors) to the questions forming the urban climate adaptation governance index. This underlines the objectivity in answering the questions based on collected information. It also shows that this index can be used by any party interested in evaluating adaptation governance efforts in mid-sized city based on available information.

Inconsequential differences are perceived, for instance, imperial college masters' students considered the metropolis PCAET covering the period 2019-2024 as one that has medium-term goals. The researcher considered medium term goals are the one to be addressed in the coming decade. Therefore, the question was modified to include "(on the horizon 2030)" to clarify what is meant by a medium-term goal. Similarly, the question "are there financial resources dedicated for monitoring and assessment at a local scale" did not seem clear, explaining the differences of answers between the researcher and the students representing an objective assessor. Consequently, having a second assessor assured the objectivity and permitted to redefine some questions forming the urban climate adaptation governance index for them to be clearer and more precise.

IV.II Feedback Loop – Developed index used as a self-assessment tool by concerned local actors

IV.II.A. City of Rouen

	Questions	Yes /No	Author	Yes/ No	Uni. Researcher	Yes /No	Rouen employee
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	1	Yes	1	Yes	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	No	0	±	0.5	±	0.5
	Is there an identification of environmental consequences to climate change?	Yes	1	Yes	1	Yes	1
	Is there an identification of socio-economic repercussions?	±	0.5	±	0.5	±	0.5
	Have the sectors impacted by climate change been identified?	±	0.5	±	0.5	±	0.5
	Is there an identification/mapping of vulnerable areas?	±	0.5	±	0.5	±	0.5
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	±	0.5	±	0.5	±	0.5
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	1	Yes	1	Yes	1
	Is there a developed regional adaptation strategy?	No	0	No	0	No	0
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	±	0.5	±	0.5	±	0.5
	Is there a developed local adaptation strategy?	±	0.5	No	0	±	0.5
	Is the developed strategy “tailored” in response to assessed impacts and vulnerabilities?	Yes	1	±	0.5	Yes	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	±	0.5	±	0.5	±	0.5

	Does the adaptation strategy include medium term plans (Horizon 2030)	No	0	No	0	No	0
	Does the adaptation strategy include long term plans? (Horizon 2050)	No	0	No	0	No	0
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	1	Yes	1	Yes	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	±	0.5	±	0.5	±	0.5
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	±	0.5	Don't know	-	±	0.5
	Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	±	0.5	Don't know	-	±	0.5
	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	±	0.5	±	0.5	±	0.5
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	±	0.5	Don't know	-	±	0.5
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	No	0	No	0	No	0
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	1	Yes	1	Yes	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	±	0.5	±	0.5	Yes	1
	Are material resources made available for the implementation	No	0	No	0	No	0

	of adaptation strategies (machines, equipment, lands etc.)?						
	Are financial resources made available for the implementation of adaptation strategies?	±	0.5	±	0.5	±	0.5
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	No	0	No	0	No	0
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±	0.5	±	0.5	No	0
	Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	1	Yes	1	Yes	1
	Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	1	Yes	1	Yes	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	±	0.5	±	0.5	±	0.5
	Are green adaptation approaches implemented?	Yes	1	Yes	1	Yes	1
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives, or disincentives (i.e., taxes or subsidies)?	±	0.5	±	0.5	±	0.5
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?	±	0.5	±	0.5	±	0.5
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	0.5	±	0.5	±	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	1	Yes	1	Yes	1

	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	1	Yes	1	Yes	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	1	Yes	1	Yes	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1	Yes	1
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1	Yes	1
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	1	Yes	1	Yes	1
	Are opportunities and levers to the implementation of adaptation identified?	±	0.5	Yes	1	±	0.5
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	1	Yes	1	Yes	1
	Is the local government supporting project studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	±	0.5	±	0.5	±	0.5
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	±	0.5	±	0.5	±	0.5
	Are existing adaptation policies periodically updated?	±	0.5	±	0.5	±	0.5
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	±	0.5	±	0.5	±	0.5
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding of	No	0	±	0.5	±	0.5
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	No	0	No	0	±	0.5
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	1	±	0.5	Yes	1

Table 19 Table comparing the author's answers to the questions forming the urban climate adaptation governance index to the answers of a climate researcher at the University of Rouen and those of a municipality of Rouen employee.

IV.II.B. City of Nijmegen

	Questions	Yes/No	Author	Yes/No	Uni. Researcher
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	1	Yes	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	Yes	1	Yes	1
	Is there an identification of environmental consequences to climate change?	Yes	1	Yes	1
	Is there an identification of socio-economic repercussions?	Yes	1	Yes	1
	Have the sectors impacted by climate change been identified?	Yes	1	Yes	1
	Is there an identification/mapping of vulnerable areas?	Yes	1	Yes	1
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	1	Yes	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	1	Yes	1
	Is there a developed regional adaptation strategy?	Yes	1	Yes	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	1	Yes	1
	Is there a developed local adaptation strategy?	±	0.5	Yes	1
	Is the developed strategy "tailored" in response to assessed impacts and vulnerabilities?	Yes	1	Yes	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	1	Yes	1
	Does the adaptation strategy include medium term plans (Horizon 2030)	±	0.5	Yes	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	1	Yes	1
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	1	Yes	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	1	Yes	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	±	0.5	±	0.5
	Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	Yes	1	Don't Know	-
	Are adaptation activities mainstreamed into various policy areas and included within existing	Yes	1	Yes	1

	policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?				
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	No	0	±	0.5
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	Yes	1	Don't Know	-
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	1	Yes	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	1	Yes	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	0.5	Don't know	-
	Are financial resources made available for the implementation of adaptation strategies?	±	0.5	±	0.5
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	±	0.5	±	0.5
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	Yes	1	Yes	1
	Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	1	Yes	1
	Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	1	Yes	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	1	Yes	1
	Are green adaptation approaches implemented?	±	0.5	Yes	1
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	Yes	1	Yes	1
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves and drought)?	±	0.5	±	0.5
		Is there a monitoring and evaluation of adaptation at a local or regional level?	±	0.5	±

Monitoring and Evaluation	Is the existing monitoring and evaluation continuous and periodic?	Yes	1	Yes	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	1	Yes	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	1	Yes	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	1	Yes	1
	Are opportunities and levers to the implementation of adaptation identified?	Yes	1	Yes	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	1	Yes	1
	Is the local government supporting project studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	1	Yes	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	±	0.5	±	0.5
	Are existing adaptation policies periodically updated?	±	0.5	±	0.5
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	1	Yes	1
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	±	0.5	Don't know	-
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	Yes	1	Yes	1
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	1	±	0.5

Table 20 Comparing the author's answers to the questions forming the urban climate adaptation governance index to the answers of an environmental researcher at the Radboud University.

IV.II.C. City of Leuven

	Questions	Yes /No	Author	Yes/ No	Municipal Councilor
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	1	Yes	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	±	0.5	Yes	1
	Is there an identification of environmental consequences to climate change?	Yes	1	Yes	1
	Is there an identification of socio-economic repercussions?	±	0.5	±	0.5

	Have the sectors impacted by climate change been identified?	±	0.5	±	0.5
	Is there an identification/mapping of vulnerable areas?	Yes	1	Yes	1
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	1	Yes	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	1	Yes	1
	Is there a developed regional adaptation strategy?	Yes	1	Yes	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	1	Yes	1
	Is there a developed local adaptation strategy?	Yes	1	Yes	1
	Is the developed strategy “tailored” in response to assessed impacts and vulnerabilities?	Yes	1	Yes	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	±	0.5	Yes	1
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	1	Yes	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	1	Yes	1
Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	1	Yes	1
	Are urbanists and city planners involved in the development and implementation of the adaptation strategy?	Yes	1	Yes	1
	Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?	Yes	1	Yes	1
	Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?	Yes	1	Yes	1
	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	1	Yes	1
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	Yes	1	Yes	1
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	±	0.5	±	0.5

	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	1	Yes	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	±	0.5	Yes	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	0.5	±	0.5
	Are financial resources made available for the implementation of adaptation strategies?	±	0.5	±	0.5
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	Yes	1	Yes	1
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±	0.5	±	0.5
	Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)	Yes	1	Yes	1
	Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	1	Yes	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	No	0	±	0.5
	Are green adaptation approaches implemented?	Yes	1	Yes	1
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	Yes	1	Yes	1
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves and drought)?	±	0.5	±	0.5
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	0.5	±	0.5
	Is the existing monitoring and evaluation continuous and periodic?	Yes	1	Yes	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	1	Yes	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	±	0.5	±	0.5
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	No	0	±	0.5

Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	±	0.5	Yes	1
	Are opportunities and levers to the implementation of adaptation identified?	Yes	1	Yes	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	1	Yes	1
	Is the local government supporting project studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	1	Yes	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	No	0	±	0.5
	Are existing adaptation policies periodically updated?	Yes	1	Yes	1
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	±	0.5	Yes	1
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	±	0.5	Yes	1
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	Yes	1	Yes	1
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	±	0.5	Yes	1

Table 21 Comparing the author's answers to the questions forming the urban climate adaptation governance index to the answers of a Leuven municipal councilor representing the Green party.

IV.II.D. City of Växjö

	Questions	Yes /No	Author	Yes/ No	Mmbr of Vaxjo Climate Commission	Yes /No	Sustainability administrator at Växjö municipality
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	1	Yes	1	Yes	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	Yes	1	Yes	1	Yes	1
	Is there an identification of environmental consequences to climate change?	Yes	1	Yes	1	Yes	1
	Is there an identification of socio-economic repercussions?	Yes	1	±	0.5	±	0.5
	Have the sectors impacted by climate change been identified?	Yes	1	Yes	1	Yes	1
	Is there an identification/mapping of vulnerable areas?	Yes	1	Yes	1	Yes	1

	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications, awareness campaigns, local environmental/climate events as well as the participation of people in these events)	Yes	1	Yes	1	Yes	1
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	1	Yes	1	Yes	1
	Is there a developed regional adaptation strategy?	Yes	1	Yes	1	Yes	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	1	Yes	1	Yes	1
	Is there a developed local adaptation strategy?	Yes	1	Yes	1	Yes	1
	Is the developed strategy "tailored" in response to assessed impacts and vulnerabilities?	Yes	1	Yes	1	Yes	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	1	Yes	1	No	0
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	1	Yes	1	Yes	1
	Does the adaptation strategy include long term plans? (Horizon 2050)	±	0.5	±	0.5	No	0
	Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	±	0.5	No	0	No
Are urbanists and city planners involved in the development and implementation of the adaptation strategy?		Yes	1	Yes	1	Yes	1
Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?		No	0	No	0	No	0
Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the		Yes	1	Yes	1	Yes	1

	development of the adaptation strategy?						
	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	1	Yes	1	Yes	1
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	±	0.5	±	0.5	±	0.5
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	±	0.5	Yes	1	Yes	1
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	1	Yes	1	Yes	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	1	Yes	1	Yes	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	±	0.5	Yes	1	Yes	1
	Are financial resources made available for the implementation of adaptation strategies?	Yes	1	Yes	1	Yes	1
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	Yes	1	Yes	1	Yes	1
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	Yes	1	Yes	1	Yes	1
	Are local authorities transparent in the implementation of adaptation measures and initiatives to prevent corruption? (i.e., are budgets made	Yes	1	Yes	1	Yes	1

	publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)						
	Has a city received an award or a label for implementing an award worthy environmental initiative?	Yes	1	Yes	1	Yes	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	1	No	0	Yes	1
	Are green adaptation approaches implemented?	Yes	1	Yes	1	Yes	1
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	Yes	1	Yes	1	Yes	1
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?	Yes	1	Yes	1	Yes	1
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	0.5	No	0	No	0
	Is the existing monitoring and evaluation continuous and periodic?	Yes	1	Yes	1	Don't know	-
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	1	±	0.5	Don't know	-
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	Yes	1	Yes	1	Yes	1
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	No	0	No	0	±	0.5
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1	±	0.5
Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	1	Yes	1	Don't know	-
	Are opportunities and levers to the implementation of adaptation identified?	Yes	1	Yes	1	Yes	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	1	Yes	1	Yes	1
	Is the local government supporting project studies conducted to	Yes	1	Yes	1	Yes	1

	improve the understanding of local impacts of climate change and to close knowledge gaps?						
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	Yes	1	Yes	1	Yes	1
	Are existing adaptation policies periodically updated?	Yes	1	Yes	1	Yes	1
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	1	Yes	1	Yes	1
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding of	Yes	1	Yes	1	Yes	1
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	Yes	1	Yes	1	Yes	1
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	1	Yes	1	Yes	1

Table 22 Table comparing the author's answers to the questions forming the urban climate adaptation governance index to the answers of a member of Växjö climate commission and those of a sustainability administrator at Växjö.

IV.II.E. City of San Sebastian

	Questions	Yes/No	Author	Yes/No	Municipality environmentalist	Yes/No	Basque Government - Ithobe
Understanding Impacts	Is there a regional vulnerability assessment of the impacts of climate change?	Yes	1	Yes	1	Yes	1
	Is there a local vulnerability assessment particular to medium sized cities (50,000-250,000)?	Yes	1	Yes	1	Don't know	-
	Is there an identification of environmental consequences to climate change?	Yes	1	Yes	1	Yes	1
	Is there an identification of socio-economic repercussions?	Yes	1	±	0.5	Yes	1
	Have the sectors impacted by climate change been identified?	Yes	1	Yes	1	Yes	1
	Is there an identification/mapping of vulnerable areas?	Yes	1	Yes	1	Yes	1
	Is the public informed of the impacts of climate change on the city? (e.g. availability of public communications,	Yes	1	Yes	1	Yes	1

	awareness campaigns, local environmental/climate events as well as the participation of people in these events)						
Developing Adaptation Strategies (Defining Tools)	Is there a national action plan delegating the responsibility to adapt to climate change to regional authorities and local governments?	Yes	1	±	0.5	±	0.5
	Is there a developed regional adaptation strategy?	Yes	1	Yes	1	Yes	1
	Are local authorities aware of the importance of adapting the territory to impacts of climate change? (i.e., has the local council declared climate emergency and is there a cabinet pushing for environmental and climate action?)	Yes	1	Yes	1	Yes	1
	Is there a developed local adaptation strategy?	Yes	1	Yes	1	Yes	1
	Is the developed strategy “tailored” in response to assessed impacts and vulnerabilities?	Yes	1	Yes	1	Yes	1
	Is the strategy prioritizing adaptation actions based on the level of urgency and the availability of resources?	Yes	1	Yes	1	Don't know	-
	Does the adaptation strategy include medium term plans (Horizon 2030)	Yes	1	Yes	1	Don't know	-
	Does the adaptation strategy include long term plans? (Horizon 2050)	Yes	1	Yes	1	Yes	1
	Implicating and Mobilizing actors	Are environmentalists and scientific experts involved in the development of the adaptation strategy?	Yes	1	Yes	1	Yes
Are urbanists and city planners involved in the development and implementation of the adaptation strategy?		Yes	1	Yes	1	Yes	1
Are local businesses and the private sector involved in the development and implementation of the adaptation strategy?		±	0.5	±	0.5	±	0.5
Is the local community (i.e., cultural forums, CSOs and non-political councils) involved in the development of the adaptation strategy?		No	0	No	1	±	0.5

	Are adaptation activities mainstreamed into various policy areas and included within existing policy and process across various sectors (e.g., agriculture, construction, maintenance etc.)?	Yes	1	Yes	1	Yes	1
	Is there a clear assignment of tasks and responsibilities (i.e., identification of department/actors responsible to develop, implement and follow up on the defined climate action)?	Yes	1	±	0.5	±	0.5
	Is there a coordination of actions and efforts among various actors in different sectors and different governance levels? (e.g., a department or actor tasked to assure the coordination between various actors)	Yes	1	Yes	1	Yes	1
	Is the city a member of a city network allowing it to connect to share knowledge, practices and experiences and join efforts with other cities (i.e. ICLEI; Eurocities etc.)?	Yes	1	Yes	1	Yes	1
Implementing Developed Strategies	Are short-terms adaptation measures and initiatives being implemented?	Yes	1	Yes	1	Yes	1
	Are material resources made available for the implementation of adaptation strategies (machines, equipment, lands etc.)?	Yes	1	±	0.5	Don't know	-
	Are financial resources made available for the implementation of adaptation strategies?	±	0.5	±	0.5	Yes	1
	Are human resources made available for the implementation of adaptation strategies? (a multidisciplinary team that possesses the skills, experience and know-how necessary to carry out the implementation of adaptation measures)?	±	0.5	±	0.5	Yes	1
	Is the civil society and the local community playing a role in supporting and enhancing the implementation of adaptation measures?	±	0.5	±	0.5	±	0.5
	Are local authorities transparent in the implementation of	Yes	1	Yes	1	Yes	1

	adaptation measures and initiatives to prevent corruption? (i.e., are budgets made publicly available? Are citizens informed of the decisions that are being taken or can they attend municipal and councilors meetings?)						
	Has a city received an award or a label for implementing an award worthy environmental initiative?	±	0.5	Yes	1	Yes	1
	Are big scale infrastructure projects or technical systems to protect the city from the impacts of climate change implemented?	Yes	1	Yes	1	Yes	1
	Are green adaptation approaches implemented?	±	0.5	±	0.5	±	0.5
	Are soft adaptation approaches implemented including warning systems, awareness Campaigns, financial incentives or disincentives (i.e., taxes or subsidies)?	±	0.5	±	0.5	±	0.5
	Did the implemented adaptation projects reduce the exposure of the city to climate risks (including floods, heatwaves, and drought)?	±	0.5	±	0.5	Yes	1
Monitoring and Evaluation	Is there a monitoring and evaluation of adaptation at a local or regional level?	±	0.5	±	0.5	Yes	1
	Is the existing monitoring and evaluation continuous and periodic?	Yes	1	Yes	1	Yes	1
	Is there personnel or a committee dedicated for monitoring and assessment at a local level?	Yes	1	Yes	1	Yes	1
	Is monitoring and evaluation based on multiple data sources across various levels (local, subnational, and national) and sectors?	±	0.5	±	0.5	±	0.5
	Are there quantitative indicators to measure the implementation of adaptation policies at a local level?	No	0	No	0	±	0.5
	Are there qualitative indicators to measure the implementation of adaptation policies at a local level?	Yes	1	Yes	1	±	0.5

Understanding Success and Limiting Factors	Are M&E reported and communicated with targeted groups to inform practice and policy?	Yes	1	Yes	1	Yes	1
	Are opportunities and levers to the implementation of adaptation identified?	Yes	1	Yes	1	Yes	1
	Are the barriers obstructing the implementation of adaptation policies and practices identified?	Yes	1	Yes	1	Yes	1
	Is the local government supporting project studies conducted to improve the understanding of local impacts of climate change and to close knowledge gaps?	Yes	1	Yes	1	Yes	1
Improving the Governance System in Place	Are vulnerability assessments updated periodically to integrate new findings and insights?	No	0	±	0.5	±	0.5
	Are existing adaptation policies periodically updated?	Yes	1	Yes	1	Yes	1
	Are local authorities aware of long-term impacts of climate change based on projections (risk assessment)?	Yes	1	Yes	1	Yes	1
	Are new adaptation policies developed based on recent vulnerability assessment and improved understanding?	Yes	1	Yes	1	Yes	1
	Are long term adaptation policies developed based on an adaptation pathway concept? (Flexibility of long-term adaptation approaches)	Yes	1	Yes	1	Yes	1
	Are emergency plans developed to overcome risks or unexpected extreme environmental events?	Yes	1	Yes	1	Yes	1

Table 23 Chart comparing the author's answers to the questions forming the urban climate adaptation governance index to the answers of an environmentalist at the San Sebastian city council and those of an Associate at the Public Society for Environmental Management of the Basque Government – Ihobe.

Appendix V: Summary Charts

Opportunities, Levers – Lessons Learnt

Challenges, Limitations – Issues to be addressed

V.I Summary Chart - Rouen

Understanding Impacts and Vulnerability	Developing Adaptation Strategies	Implicating and Mobilizing Actors	Implementing Developed Strategies	Monitoring and Evaluation	Understanding Limiting and Success Factors	Improving Governance System in Place
Local IPCC established at the scale of the metropolitan area of Rouen.	The city of Rouen has its own agenda 21 and the metropolis developed a local Cop21 initiative.	The Accord of Rouen at the scale of the metropolis engaging various actors.	Seine bank rehabilitation project → climate change not a concern for the development of the project but the latter serves as a buffer zone in times of floods. Various Greening Initiatives.	The Cit'ergie label evaluates the action of cities and communities in the context of climate action and ecological transition.	Development of annual sustainable reports.	The city developed a municipal protection plan to increase its resilience and preparedness to various events of emergency including natural risks.
Local actors are aware of the impacts of CC on their territory and the importance of addressing the issue.	Willingness to go beyond legal requirements.	The establishment of the Cop21 Workshop and online platforms to improve the mobilization of actors.	Small scale experimentation projects (Zac Luciline).	An external cabinet makes an objective evaluation.	Local actors are aware of the barriers to the implementation of adaptation policies and measures.	Climate projections present changes in climate conditions on the horizons 2030, 2050 and 2080.
The awareness of local residents is still insufficient with regard to the impacts of CC on their territory.	No coordination across different levels of governance.	Lack of a real participatory governance.	Lack of technical financial and human resources.	The monitoring and Evaluation tool is more focused on mitigation.	Need for more research and studies in order to close knowledge gaps.	The update of impact assessments as well as adaptation policies is not consistent.
More research is needed particularly at the scale of the city of Rouen.	No adaptation plan has been developed. Yet, adaptation strategies have been included in the air-climate-energy plan.	Various departments still work in silos.	Many public projects are not aligned with the intention of ensuring a sustainable development at the scale of the territory (Contradiction).	Monitoring and Evaluation systems are still at their embryotic stage.	There is no clear identification of levers and opportunities as adaptation measures are still at an experimental level.	Absence of long-term vision and adaptation plans.

Table 24 Summary Chart - Case of Rouen.

V.II Summary Chart – Nijmegen

Understanding Impacts and Vulnerability	Developing Adaptation Strategy	Implicating and Mobilizing Actors	Implementing Developed Strategies	Monitoring and Evaluation	Understanding Limiting and Success Factors	Improving Governance System in Place
Maps are developed to understand the vulnerability of the city to droughts, floods, and extreme heats. + green and blue infrastructure mapping.	→ NL is engaged in a strategy of strong anticipation. → The city adopts a Spatial Adaptation approach. Its adaptation policy is encompassed in the present policy plans.	The regional government guides and advises the water authorities and the municipalities in the implementation of adaptation measures.	Nijmegen is one of the major urban examples for the implementation of the 'Room for the River' project, introduced by the national government.	The office for Research and Statistics at the municipality of Nijmegen is using an annual city and neighborhood monitor to provide an image of the state.	In NL more consideration is being given to creating links between climate adaptation measures and other tasks at an urban scale → increased acceptability of projects + financial benefits.	New environmental Act → room for general rules instead of detailed permits which → simplified procedures (reducing time and costs).
Previous floods leading to the evacuation of residents → Wakeup call on the importance of dealing with river and pluvial floods.	Nijmegen approved the Room for the Waal plan in 2007, as an appropriation of the national 'Room for the river' program → give room for river to prevent floods.	The water authorities work closely with municipalities → they exchange information and join initiatives. Water boards also raise the awareness of businesses, architects, and citizens.	Various greening initiatives are implemented, subsidies are provided for the separation of rainwater from sewage, green facades and green roofs.	The city & neighborhood monitor looks at various programs i.e. administratio, organization, population, cultural heritage, economy and tourism, education, accessibility, public space, etc.	Success factors: - Financial & technical support provided by the national government - Coordination of efforts and engagement of various stakeholders - Involvement of local community -Creating synergies.	More money made available to stimulate and facilitate climate adaptation & implement emergency measures (e.g., extra pumps) to address the issue of prolonged summer droughts.
The country is not exempted from dealing with a reduced water availability → agricultural lands were impacted in Nijmegen.	The city doesn't have an adaptation plan. To offset the lack of a local adaptation plan, the city relies on the regional adaptation plan.	The realization process of the room for the Waal project involved discussions & collaborations with various stakeholders to address concerns.	The implementation of the room for the Waal project wasn't easy because the destruction of around 50 houses was necessary to widen the river and create more space for water.	The city doesn't have specific indicators to monitor the progress of adaptation measures, especially that it has not yet developed a proper adaptation plan.	Limiting factors: - Expropriation of lands and properties & compensation schemes - Budget constraints - Citizens are not very much aware of available subsidies.	Efforts are required to ensure the city is climate proof by 2050.

Table 25 Summary Chart - Case of Nijmegen.

V.III Summary Chart – Leuven

Understanding Impacts and Vulnerability	Developing Adaptation Strategies	Implicating and Mobilizing Actors	Implementing Developed Strategies	Monitoring and Evaluation	Understanding Limiting and Success Factors	Improving Governance System in Place
The Flemish Climate Policy Plan (VKP) presents the impact on CC on natural systems, on society and on various sectors.	Federal Structure → important competencies for regional authorities - Flemish adaptation plan (2013) + Drought & flood action plan (2019-2021).	Non-profit organization (Leuven 2030) established uniting residents, companies, knowledge institutions and public authorities.	Leuven guarantees the implementation of its climate neutral plans by embedding it within the regular operation of various city services.	A federal law set the framework for M&E → all federal authorities & departments required to communicate data relevant to CC a yearly basis to ensure consistency.	The Flemish government developed and published a series of assessment reports.	A new VAP (2021-2030) has been approved by the Flemish government, building on the and results from the previous VAP (2013 – 2020).
A federal government pact endorsed an open data policy with an improved access to public data → Data available for interested parties.	- Local agenda 21 established in 1992. - City roadmap 2025 2035 2050 developed in 2018 → increasing urban resilience.	Leuven 2030 plays a crucial role in stimulating environmental and sustainable projects in the city.	the Dijle’s valley-grounds have been restored to become natural zones for flooding (storing more than 2 million m ³ of water).	The city’s climate plan (2020-2025) defines for each measure the indicators to monitor its implementation.	Success factor: the developed roadmap is based on acquainted knowledge but is subject to change based on new insights (Flexibility).	A new river basin management plan is to be developed for the period 2022-2027. Leuven’s roadmap has a forward thinking.
Leuven 2030 organization collaborate with the local university to produce knowledge at a local scale. Yet this knowledge is rather focused on GHG emissions and sustainable development.	The city roadmap is focused more on sustainable development and mitigation rather than adaptation.	There is a lack of collaboration between the federal government and the municipal council (different political point of view).	The lack of financial resources could impede the implementation of adaptation measures at a local scale.	Flemish government is working on developing a more thorough monitoring and evaluation adaptation system and indicators for its VAP 2021-2030.	Challenges: Fragmentation of available data (difficult access); Lack of cash flow to invest in climate measures; Pressure on emergency resources.	No contingency plans have been developed at a local scale to respond to risks that are linked to climate change.
Most vulnerability and impact studies are conducted at a national or regional level.	The prioritization of areas of action is mainly based on emissions rather than adaptation needs.		As adaptation is a “new” area of focus at the city scale, to date mostly a few small-scale initiatives have been implemented.	There is a need for more environmental knowledge and data specific to Leuven to monitor and evaluate the results.	Local municipalities were until recently little involved in the policy.	Covid19 impacted the organization of the Leuven 2030 Congress.

Table 26 Summary Chart - Case of Leuven.

V.IV Summary Chart – Växjö

Understanding Impacts and Vulnerability	Developing Adaptation Strategies	Implicating and Mobilizing Actors	Implementing Developed Strategies	Monitoring and Evaluation	Understanding Limiting and Success Factors	Improving Governance System in Place
2010 – Kronoberg County developed Regional Climate and Vulnerability Analysis – Risk for floods and high flows’.	-Political parties have unanimously agreed on the importance of addressing environmental issues.	Decentralized country Horizontal model of governance & strong sense of commitment.	The municipality has a large env. budget (tax on salaries) allowing the execution of projects.	Natural resources are managed with the same diligence as financial resources, using an ecological accounting system (Ecobudget).	The city of Växjö have produced annual report since 2007 to present and assess the alignment of environmental actions with the defined long-term objectives.	Local gov. is aware that adaptation is an ongoing process, and a new adaptation plan was developed in 2021 based on new insights.
In 2011, the city of Växjö conducted a risk and vulnerability analysis (RSA).	Environmental policy (1993) Local agenda 21 (1999) Adaptation plan (2013) Green Strategy (2013).	Municipality collaborating with biggest environmental NGO in Sweden (SSNC) to guide its action.	Development of new districts → “focusing on people in the design rather than starting from the idea that cars should dominate”.	Each administration now has the responsibility to report to the municipality’s environmental coordinator.	There is a political unity, commitment and will to address environmental issues.	Public warning system (VMA) is developed. Rescue services are prepared. Crisis support group is in place to support affected people.
The citizens of Växjö have a high level of awareness as environmental education is ensured in secondary schools.	Eutrophication of lakes (1960s) + Oil crisis (1970) provoked the interest of local authorities in environment and energy management.	Roundtable exchanges between citizens, businesses and local NGOs were the basis for the development of the local agenda 21.	- Construction of Linneaus Canal → prevent flooding - Integrated storm water management systems - Green city (90% of citizens live within 300m of green areas).	The city has qualitative indicators to measure adaptation progress (degree of progress) rather than quantitative indicators.	Success factors: Decentralization; available budget (success /transparency facilitated the obtention of funds) - cooperation among different actors.	Projections are developed allowing to build an improved understanding of future weather conditions and their impacts.
The collaboration of the municipality with the local university to produce knowledge is focused on sustainable development and mitigation	The city’s adaptation action plan does not specify the budget and timeframe of each action to be conducted and does not elaborate on long-term	There is no clear assignment of tasks and responsibilities , and the coordination of actions does not persist in the implementation phase.	The municipality can take measures in the buildings that it owns (I.e., schools). However, it cannot take actions in buildings and	City needs to develop a more thorough monitoring and evaluation system to assess adaptation efforts.	Limiting factors: -Not all properties and lands are owned by the municipality -It is challenging to adapt old and existing built areas	The city needs ot further invest in adaptation measures as “it can’t live on old merits” (sustainability administrator at Växjö municipality

rather than adaptation.	adaptation plans.		lands that it does not own.		-Influencing behavior.	(interview, 2020).
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Table 27 Summary Chart – Case of Växjö.

V.V Summary Chart – San Sebastian

Understanding Impacts and Vulnerability	Developing Adaptation Strategies	Implicating and Mobilizing Actors	Implementing Developed Strategies	Monitoring and Evaluation	Understanding Limiting and Success Factors	Improving Governance System in Place
<p>In 2010, the Basque government mapped the impacts of climate change on the region.</p> <p>In 2015, a thorough diagnosis was carried out at the scale of San Sebastian in preparation for the city's adaptation plan.</p>	<p>The national government → coordinate climate action.</p> <p>The Basque country region → competencies related to environmental plans.</p> <p>The municipality of San Sebastian → responsibility to develop an urban plan.</p>	<p>Basque climate strategy developed in collaboration with scientists, researchers, all ministries forming the Basque government as well as provincial and local councils.</p>	<p>A submersible river park is being developed to increase the resilience of the Txomin Enea district to floods. + Urumea Channel is being broadened from the current 25 meters to 50 meters.</p>	<p>To monitor its climate strategy, the Basque country developed a "datasheet of the degree of compliance of the actions".</p>	<p>The city's exposure to imminent risks of sea level rise has pushed the city to further develop adaptation policies and develop measures ensuring the resilience of the territory to projected impacts.</p>	<p>The Basque climate strategy sets a timeline at the horizon 2050 with an initial period for the implementation of policies between 2015 and 2020. And a 2nd implementation period between 2020 and 2030.</p>
<p>Simulations are conducted (based on various climate scenarios) showing the impacts of the sea level rise on the city of San Sebastian.</p>	<p>Basque government developed a climate strategy (Klima 2050). And defined 70 lines of action, including adaptation plans, for the first period.</p>	<p>'Udalsarea" network brings together 200 Basque municipalities. + Basque Center for Climate Change, known as the "BC3", brings together 35 researchers from 12 different countries.</p>	<p>The city has various parks and green areas that have existed for a while and are not particularly developed to ensure climate adaptation but have increased the resilience of the territory to climate events</p>	<p>The Basque country committed itself to develop monitoring reports on a 2 yearly basis as of 2017 and "Interim assessment reports" every 10 years as of 2020.</p>	<p>Levers – San Sebastian: - The city's commitment to leading climate action - Competent team of experts that assures and follows up on the implementation of measures. - The team's motivation to participate in innovate projects.</p>	<p>The San Sebastian climate action plan DSS Klima2050, sets out general objectives for 2050.</p>
<p>The city has developed vulnerability maps and has a clear identification of areas and</p>	<p>The city developed its own adaptation plan presenting 31 concrete</p>	<p>In San Sebastian a technical commission for adaptation was created, incl. members</p>	<p>The garden city of Loiola project is developed to protect the area against possible floods.</p>	<p>San Sebastian monitors the degree of progress in the implementation of adaptation measures but</p>	<p>Challenges (regional scale): - uncertainty and lack of knowledge - need for effective</p>	<p>The city is planning on reviewing the general urban planning strategy criteria as of 2020 to</p>

neighborhoods that are vulnerable to floods and urban heat island effect.	actions. It also developed a 2050 roadmap and adopted it in 2018.	from various departments, e.g., projects and works; town planning; firefighting; maintenance and urban services; social welfare etc.		hasn't yet developed quantitative indicators.	implementation of policies - Creating synergies - drive economic prosperity and climate and energy investments.	define climate regulations in the urban license management and is investigating the possibility of implementing nature-based solution.
Drought and lack of water availability is not really considered an issue in this city and is not mentioned.	Authorities asserted that developing new strategies is not enough → need for behavioral and cultural change.	To date there is no formal procedure allowing for the participation of citizens and local businesses in the decision making.	There is some delay in the implementation of projects (e.g., Loiola garden) due to lack of resources.	The SmartKalea initiative allows for monitoring and evaluation but of mitigation rather than adaptation efforts.	Challenges (San Sebastian) - Short termism - Climate change seems abstract to many. - The city's location on the coast increases its vulnerability - securing the budget for the implementation of projects.	The city -at risk of floods and forest fires- developed emergency plans in response.

Table 28 Summary Chart - Case of San Sebastian.

Appendix VI: Introduction & Conclusion in French

This part integrates a French translation of the introduction and conclusion in respect to the doctoral school's requirements.

VI.I Introduction

Le changement climatique est un sujet d'intérêt mondial qui préoccupe des chercheurs, des scientifiques, des experts ainsi que des décideurs politiques depuis des décennies.

Van der Gaast & Begg (2012) ont déclaré que ce phénomène mondial et « ses conséquences en raison des émissions anthropiques de gaz à effet de serre (GES) sont parmi les problèmes environnementaux les plus redoutables dans le monde aujourd'hui ». Adger et coll. (2003) ont indiqué que le changement climatique est sans doute la menace la plus persistante pour la stabilité mondiale du 21^{ème} siècle. Les scientifiques ont prévu qu'en raison du changement climatique, les événements météorologiques extrêmes évolueront pour être plus fréquents et intenses dans les années à venir, provoquant un large éventail d'impacts affectant divers secteurs et régions du monde (Aykut & Dahan, 2014 ; Burch et Harris, 2014).

De plus en plus de personnes dans le monde prennent conscience de la gravité de ce problème, car des impacts majeurs ont émergé, tels que des conditions météorologiques extrêmes et de nouveaux records de température dans différents pays et régions (Fagan & Huang, 2019). Divers événements, tels que les incendies de forêt amazoniens de 2019 et la vague de chaleur européenne de juillet 2019 (qui ont établi de nouveaux records de températures), ont été des « révélations » pour les populations du monde entier sur l'importance de s'attaquer au problème du changement climatique et de renforcer la résilience des territoires. En outre, les inondations estivales qui se sont produites en Europe occidentale en juillet 2021, qui ont touché principalement le Royaume-Uni, l'Allemagne, la Belgique et la Suisse, et entraîné la mort de plus de 190 personnes, ont souligné les dommages qui pourraient survenir en raison du changement climatique, même dans certains des pays les plus développés qui avaient déjà investi dans la prévision et la préparation des inondations (Cornouailles, 2021).

À l'échelle mondiale, l'idée d'aborder les questions environnementales et d'assurer un développement durable a atteint son apogée depuis les années 1990 (Aykut & Dahan, 2014). Le sujet a suscité une attention particulière de la part de diverses parties appelant à une action mondiale, y compris différents niveaux gouvernementaux et représentatifs de divers secteurs, organisations, décideurs, entreprises, chercheurs et scientifiques (Aykut & Dahan, 2014).

La série de rapports rédigés par le GIEC ainsi que d'autres scientifiques, résumant les faits sur le sujet, ont été cruciales pour susciter l'intérêt international pour s'attaquer au problème (Martin, 2015). Ces rapports ont mis en évidence comment l'activité humaine est l'une des principales causes du changement climatique.

Lors de la Conférence des Nations Unies sur les changements climatiques de 2010, un accord a été conclu pour limiter le réchauffement climatique à 2,0 ° C (3,6 ° F) au-dessus du niveau préindustriel. Cinq ans plus tard, l'accord de Paris a amené 195 pays à une responsabilité commune pour assurer un avenir sobre en carbone, durable et résilient. Cet accord (CCNUCC, 2015) vise à renforcer

l'action mondiale face aux risques du changement climatique en agissant non seulement pour limiter les émissions de GES, mais aussi en garantissant des approches résilientes au climat et en améliorant la capacité d'adaptation aux effets négatifs du changement climatique (Aykut & Dahan, 2014).

La réduction des émissions est cruciale pour faire face au problème du changement climatique et limiter l'augmentation de la température mondiale. Cependant, il semble inévitable de prendre des mesures pour adapter la planète aux changements climatiques. Surtout que les chercheurs ont montré que même si les émissions devaient s'arrêter aujourd'hui, la planète continuerait à se réchauffer et le monde fera encore face aux conséquences du changement climatique pendant des décennies (Frölicher, Winton et Sarmiento, 2013).

Cette thèse est axée sur l'Europe en particulier étant donné que les Etats membres de l'Union européenne (UE) sont mis d'accord sur la réduction des émissions de GES et l'amélioration de l'efficacité énergétique. La Commission européenne (CE) a également adopté une stratégie d'adaptation au niveau de l'UE et incité ses États membres à élaborer des plans nationaux pour gérer les impacts inévitables du changement climatique.

ÉNONCÉ DU PROBLÈME

Au fil des années, les actions à l'échelle mondiale et européenne ont été principalement axées sur la réduction des émissions de GES plutôt que sur l'adaptation des territoires et l'augmentation de leur résilience face aux changements climatiques. « Alors que de nombreuses villes en Europe travaillent déjà à atténuer les effets du changement climatique, l'adaptation aux risques climatiques reste un nouveau défi pour beaucoup d'entre elles » (Lukat et coll., 2016).

Malgré les efforts mondiaux et transnationaux pour prendre des mesures appropriées, le problème s'exacerbe. Divers phénomènes météorologiques extrêmes se sont manifestés et sont susceptibles d'augmenter à la lumière du réchauffement climatique, ayant un impact direct sur les pays, les régions et les villes et ayant d'autres ramifications socio-économiques sur leurs habitants (NASA, 2021). Dans son rapport sur les risques mondiaux pour l'année 2020, le Forum Économique Mondial a classé respectivement les « échecs de l'action climatique », la « perte de biodiversité », les « conditions météorologiques extrêmes » et la « crise de l'eau » comme les 1^{er}, 3^{eme}, 4^{eme} et 5^{eme} menaces mondiales parmi les « 5 principaux risques mondiaux en termes d'impact » (Forum Économique mondial, 2020).

Le GIEC (2021), dans son 6^{eme} rapport d'évaluation, a affirmé que « les zones urbaines et les villes seront affectées par des événements climatiques extrêmes plus fréquents ». Un associé du centre international pour le changement climatique et le développement (ICCCAD) (interview, 2018) a expliqué que, généralement, les villes sont vulnérables à ce problème mondial, puisque, historiquement, les établissements humains - qui sont devenus les villes que nous connaissons aujourd'hui - ont été fondés à proximité des eaux de surface (rivières, mers, océans, etc.) pour permettre le commerce, le transport et la connectivité. Cette situation géographique les expose à un grand risque d'élévation du niveau de la mer, d'inondations, de fortes pluies et de tempêtes fréquentes. De plus, les villes sont des lieux de concentration de systèmes d'infrastructures physiques et sociales qui les rendent plus exposées aux risques naturels et environnementaux et

donc plus vulnérables (Associé à l'ICCCAD, interview, 2018). La situation est particulièrement alarmante car, selon une fiche technique développée par le Population Reference Bureau (2016), environ 60% de la population vit aujourd'hui dans les villes et ce pourcentage devrait atteindre au moins 70% de la population mondiale d'ici 2050.

Les conditions météorologiques extrêmes provoquées par le changement climatique sont susceptibles d'avoir une série de conséquences aggravantes. Ces événements météorologiques pourraient perturber l'activité quotidienne et avoir d'autres ramifications économiques. Des exemples sont observés chaque année avec des centres urbains qui se noient à la suite de fortes pluies ou d'inondations de rivières. Par exemple, selon un article de presse, l'ouragan Harvey qui a frappé le Texas en 2017 a touché 13 millions de personnes et causé 125 milliards de dollars de dommages (World Vision Staff, 2018).

Cette recherche se concentre sur les villes moyennes en Europe en particulier étant donné que, selon les données produites par la Direction générale de la politique régionale et urbaine de la Commission européenne (Dijkstra & Poelman, 2012), la plus grande partie de la population urbaine de ce continent vit dans des villes de cette échelle. Diverses sources ont également souligné que les villes de taille moyenne présentent un domaine d'étude sous-développé. Par exemple, Giffinger *et al.* (2007) ont déclaré que les villes de taille moyenne ont été relativement négligées par les organisations internationales et les chercheurs, probablement en raison de l'intérêt de la recherche urbaine sur les grandes villes ou les métropoles « mondiales ». Živanović *et al.* (2014) ont affirmé que « les documents statistiques et autres documents d'information relatifs aux villes de taille moyenne disponibles au niveau européen sont plutôt limités et manquent de comparabilité conceptuelle ». Un rapport de l'Agence européenne pour l'environnement sur l'adaptation urbaine au changement climatique en Europe (2016) a souligné que les petites et moyennes villes sont souvent liées à des réseaux urbains avec diverses zones métropolitaines ou grands centres urbains, mais qu'elles disposent de ressources différentes pour relever les défis et faire face à des conditions différentes.

Les villes de cette taille sont considérées comme vulnérables au changement climatique car elles exposent des millions de personnes et un grand nombre d'infrastructures aux impacts du changement climatique. D'autres facteurs pourraient maximiser la susceptibilité de ces villes, comme leur emplacement et leur urbanisation rapide. Les villes de taille moyenne sont susceptibles de se trouver désavantagées par rapport aux grandes villes, car elles pourraient avoir des ressources techniques et financières limitées ainsi que des systèmes d'infrastructures urbaines défaillants qui limitent leur résilience (Mungo, 2017; Filho *et coll.*, 2019). Smart Cities Consulting GmbH (2018) a déclaré sur sa plate-forme en ligne que « de nombreuses grandes villes comme Berlin, Londres ou Vienne sont déjà dotées d'une stratégie d'adaptation au changement climatique, mais de nombreuses petites et moyennes villes manquent de données de base ou même de sensibilisation à ce problème ».

Dans une note de discussion élaborée par le Programme des Nations Unies pour le développement, le Fonds de développement des immobilisations, et le Programme pour l'environnement en 2010, il a été déclaré que les gouvernements locaux ont un rôle important à jouer dans la réponse aux impacts du changement climatique, car il s'agit de problèmes très localisés et les réponses nécessaires sont souvent spécifiques à un contexte donné. Cependant, étant donné que le changement climatique est une question d'intérêt mondial, les autorités locales

des villes de taille moyenne pourraient être confrontées à des défis particuliers pour résoudre le problème. Elles pourraient manquer de motivation, de ressources ou de connaissances pour prendre des mesures appropriées. « L'énormité et la complexité de la préparation aux catastrophes liées aux conditions météorologiques limitent la capacité des gouvernements locaux à faire face à ces phénomènes » (McArdle, 2014).

Pour ces raisons, une attention particulière doit être accordée à l'adaptation des villes de taille moyenne. Cette thèse met donc l'accent sur le thème de la gouvernance de l'adaptation au changement climatique dans les villes européennes de taille moyenne.

OBJECTIF ET QUESTIONS DE RECHERCHE

Cette thèse a un double objectif. Premièrement, elle vise à souligner l'importance de l'adaptation au changement climatique à l'échelle locale. Deuxièmement, elle vise à améliorer les connaissances sur les relations entre les systèmes de gouvernance de l'adaptation, l'évaluation des solutions mises en oeuvre et une gamme d'impacts climatiques et de vulnérabilité dans différentes villes moyennes en Europe.

Pour atteindre ces objectifs, la thèse aborde une question de recherche principale : les efforts de gouvernance des autorités locales dans les villes européennes de taille moyenne contribuent-ils à augmenter la capacité d'adaptation du territoire aux événements climatiques ?

Pour répondre à cette question de recherche, des sous-questions sont abordées, d'une part, pour analyser les efforts des gouvernements locaux en place pour s'adapter au changement climatique, ainsi que les opportunités et les défis rencontrés par les autorités locales dans les villes européennes de taille moyenne à travers l'élaboration et la mise en oeuvre de politiques d'adaptation. D'autre part, pour déterminer les approches de gouvernance permettant d'améliorer la capacité d'adaptation des villes de taille moyenne et augmenter leur résilience climatique.

Cette thèse souligne l'importance de la gouvernance climatique et suppose que l'élaboration et la mise en oeuvre de politiques d'adaptation au changement climatique augmentent la résilience d'un territoire aux impacts. Elle suppose également que la capacité des villes à faire face aux enjeux climatiques est dépendante de leur échelle, du système de gouvernance en place (i.e., centralisé vs. décentralisé) ainsi que des priorités et de la motivation des autorités locales.

Ces hypothèses sont considérées comme des points de départ pour une analyse plus approfondie. Une approche comparée, à partir d'études de cas, est adoptée pour répondre aux questions de recherche et confirmer ou infirmer ces hypothèses.

Pour atteindre l'objectif affiché, répondre aux questions de recherche et vérifier les hypothèses, ce volume commence par une revue de littérature sur les impacts du changement climatique, les approches et stratégies d'adaptation, la gouvernance du changement climatique ainsi que les outils d'accompagnement pertinents (chapitre 2). Cette thèse présente ensuite la méthodologie adoptée incluant le cadre de recherche, la stratégie, les limites ainsi que les méthodes de collecte et d'analyse des données. Dans le cadre de la méthodologie, un indice est conçu et présenté pour évaluer les efforts des gouvernements locaux dans l'adaptation des villes moyennes d'Europe aux

événements climatiques pour augmenter leur résilience (chapitre 3). Chacune des études de cas sélectionnées est ensuite présentée avec un détail des différentes réponses d'adaptation mises en place pour faire face aux impacts -sur la base des informations extraites des entretiens menés et d'un examen des structures institutionnelles, des politiques mises en œuvre ainsi que des stratégies développées pour adapter l'infrastructure urbaine au changement climatique. Les données primaires et secondaires présentées sont utilisées pour évaluer la gouvernance urbaine de l'adaptation de chacune des villes de taille moyenne sélectionnées (chapitre 4). Une analyse croisée permet de comparer les efforts de différentes villes européennes de taille moyenne pour s'adapter au changement climatique (chapitre 5). Une boucle de rétroaction est ensuite présentée pour discuter de la méthodologie et déterminer comment l'indice de gouvernance de l'adaptation proposé peut être encore amélioré sur la base de la réponse des acteurs clés de la ville qui ont testé cet indice comme outil d'auto-évaluation. À la suite de cette discussion, la conclusion de la thèse cherche à savoir si les systèmes de gouvernance existants permettent d'améliorer la capacité d'adaptation des villes au changement climatique et présente des recommandations pour de futures recherches (chapitre 6).

VI.II Conclusion

Ce travail de recherche visait à déterminer si les efforts de gouvernance des autorités locales dans les villes européennes de taille moyenne contribuent à accroître la capacité d'adaptation du territoire et sa résilience aux événements climatiques.

Par conséquent, des questions ont été soulevées pour mieux comprendre les efforts actuels en place pour s'adapter au changement climatique dans une série de villes qui sont -sur la base des critères de sélection- considérées comme des pionnières dans ce domaine. Ces efforts comprennent une compréhension des impacts, la mobilisation des acteurs, l'élaboration, la mise en œuvre et le suivi des stratégies d'adaptation, l'identification des leviers et des verrous ainsi que l'amélioration continue du système de gouvernance en place. Pour évaluer si l'approche de gouvernance adoptée pour s'adapter au changement climatique, dans chacune des études de cas sélectionnées, est adéquat permettant d'assurer une ville résiliente, un indice a été conçu pour évaluer la gouvernance de l'adaptation sur la base de 50 indicateurs.

Cette méthodologie a permis de comparer les efforts d'adaptation des différentes villes moyennes et de définir les domaines de gouvernance auxquels la ville doit consacrer plus d'efforts. L'outil pourrait également être utilisé par les autorités locales comme guide pour l'adaptation au changement climatique.

Les résultats de la recherche et de l'étude comparative ne peuvent pas être généralisés car les études de cas sélectionnées ne présentent qu'un petit échantillon et ne décrivent pas nécessairement la situation de toutes les villes européennes de taille moyenne. Cependant, ces résultats présentent un aperçu général et permettent une meilleure compréhension des défis et des opportunités de la gouvernance de l'adaptation au changement climatique dans les villes moyennes.

En conclusion, les résultats de cette recherche ont montré que les villes européennes de taille moyenne pourraient être exposées à des impacts similaires du changement climatique,

notamment des inondations (pluviales, fluviales ou côtières), de fortes tempêtes, des vagues de chaleur et, moins nettement, le manque de disponibilité en eau. Cependant, l'intensité de ces impacts et la vulnérabilité du territoire varient d'un cas à l'autre en fonction de divers facteurs, tels que la géographie du territoire (par exemple : zones côtières vs. zones intérieures), la densité de la zone bâtie, les facteurs démographiques (par exemple : le vieillissement de la population et la croissance démographique) ainsi que les efforts de divers acteurs de la ville pour prendre des mesures climatiques proactives et réactives. Il est donc essentiel de comprendre la spécificité de chaque cas pour déterminer sa vulnérabilité.

Des évaluations de la vulnérabilité et de l'impact ont été élaborées par différents niveaux de gouvernance en collaboration avec des experts, des consultants ou des universitaires des universités locales. Néanmoins, il semble y avoir plus de connaissances aux niveaux national et régional et à l'échelle des zones métropolitaines et des grandes villes. Cela souligne la nécessité de développer davantage les connaissances à l'échelle locale, en particulier dans le cas des villes de taille moyenne.

Développer ces connaissances en collaboration avec divers experts est essentiel, néanmoins la communication et la « vulgarisation » des données scientifiques produites sont cruciales. Dans les études de cas examinées, malgré la production d'évaluations d'impact locales et l'intérêt accru du public pour les questions environnementales et climatiques, beaucoup semblent encore ne pas comprendre comment le changement climatique pourrait avoir un impact sur leur vie quotidienne. Le changement climatique pourrait être perçu par beaucoup comme loin de leurs préoccupations personnelles. La sensibilisation et l'intérêt du public semblent augmenter à la suite de la survenue d'événements climatiques (par exemple canicule ou inondations) mais ce n'est pas toujours une constante comme cela a été souligné dans le cas de Rouen. Les gens reviennent à leurs habitudes et font les choses comme ils en ont l'habitude une fois l'événement climatique terminé. Un changement de comportement et de culture est donc fondamental. Les expériences des villes sélectionnées ont révélé que l'inclusion des connaissances climatiques et environnementales dans les programmes scolaires et les pratiques des professionnels pouvait susciter ce changement culturel et comportemental.

La survenue d'événements climatiques extrêmes semble avoir incité les gouvernements locaux à adapter le territoire au changement climatique (par exemple, les inondations à Nimègue et à Louvain, les vagues de chaleur à Rouen, les tempêtes côtières à Saint-Sébastien, etc.). La visualisation des impacts rend la question plus réelle et personnelle en exhortant les acteurs responsables à agir. Cependant, « il a été démontré qu'une action d'adaptation précoce et bien planifiée permet d'économiser de l'argent et des vies plus tard » (Commission européenne, s.d.). Par conséquent, les gouvernements ne devraient pas attendre et réagir de manière réactive, mais devraient plutôt élaborer des mesures proactives, fondées sur la compréhension des risques et des vulnérabilités.

En plus d'être exposées aux menaces environnementales, diverses motivations semblent avoir poussé les autorités locales des villes de taille moyenne à s'attaquer aux problèmes climatiques : cela pourrait être une obligation légale, ou leur conviction personnelle, la nécessité de mieux faire les choses, et de voir l'action climatique comme une opportunité d'augmenter la qualité de vie de la ville, d'attirer les investissements ainsi que les touristes. Quelle que soit la motivation initiale

pour élaborer et mettre en œuvre des mesures d'adaptation, la continuité et les engagements politiques sont cruciaux.

Étant donné que le mandat politique varie généralement entre 4 et 6 ans, les maires élus sont sous pression pour démontrer leur performance dans un court délai. Par conséquent, ils ont tendance à s'intéresser à la mise en œuvre de projets à court terme qui ont un retour sur investissement rapide, car cela pourrait avoir une incidence sur leurs chances d'être réélus. Cela contredit toutefois le calendrier à long terme nécessaire à la mise en œuvre d'actions d'adaptation visant à accroître la résilience du territoire (Agence régionale de l'environnement de Normandie, entretien, 2019).

Les élections locales pourraient également entraîner des changements dans les priorités abordées par le conseil municipal, affectant le budget consacré aux engagements climatiques. Cela souligne l'importance d'assurer un environnement politique stable dans lequel la continuité des efforts d'adaptation n'est pas affectée par les élections locales. Comme par exemple, dans le cas de Växjö, où tous les partis politiques ont convenu à l'unanimité d'aborder les questions environnementales.

Outre du court-termisme lorsqu'il s'agit de concevoir un projet pour des raisons politiques, les cas examinés ont mis en évidence que les villes ont tendance à mettre en œuvre des initiatives à court terme et de faible ampleur pour s'adapter au changement climatique pour des raisons financières. Les résultats ont souligné que les municipalités locales des villes européennes de taille moyenne sont confrontées à un défi majeur qui entrave la mise en œuvre des projets d'adaptation : le manque de ressources financières. Ce problème affecte la disponibilité de ressources humaines et techniques adéquates et entrave le développement de projets à grande échelle qui, à court terme, nécessitent des investissements plus importants.

Les projets à petite échelle semblent nécessiter moins de capitaux tels que le développement d'initiatives de verdissement pour augmenter la perméabilité des sols et réduire l'impact des vagues de chaleur, l'organisation d'événements environnementaux et la mise en place d'incitations à mobiliser les acteurs. Cependant, comme le changement climatique pourrait entraîner des impacts graves, des changements radicaux et le développement ainsi que la mise en œuvre d'initiatives à long terme et à grande échelle telles que « Room for the Waal River » (Nimègue) seront nécessaires. L'adaptation nécessite des changements systémiques, y compris des transformations dans les organisations sociales, juridiques et politiques, des changements dans les modèles individuels complétés par le progrès technologique (Sokoloff, 2016).

Pour relever le défi financier, les résultats ont souligné que diverses initiatives de financement sont développées au niveau local, régional et national (par exemple, budget environnemental, aides, initiatives de financement participatif). Il existe également des systèmes de financement au niveau européen. Cependant, il demeure nécessaire de faciliter l'accès à ces financements et rendre les investissements climatiques plus attrayants. La simplification des procédures (comme l'a fait le gouvernement néerlandais en approuvant une nouvelle loi sur l'environnement), permettant de réduire la bureaucratie et laissant la place à des règles générales au lieu de permis détaillés, pourrait inciter au financement et au développement d'approches et de projets d'adaptation innovants.

Les acteurs locaux dans les cas examinés ont souligné que le public et divers acteurs municipaux de différents services sont plus familiers avec les notions de développement durable et d'atténuation du changement climatique plutôt que d'adaptation. À Rouen par exemple, l'action climatique est souvent perçue ou considérée comme limitée aux questions de tri et de valorisation des déchets, de création de pistes cyclables, de limitation des émissions et d'augmentation de la part des énergies renouvelables (Lesconnec, 2017). D'autres actions liées à l'adaptation du territoire et à l'augmentation de sa résilience au changement climatique restent inconnues au public. Pour ajouter à cela, dans les politiques environnementales et climatiques élaborées, les plans d'action ont tendance à être axés sur l'atténuation du changement climatique et moins de mesures sont proposées pour protéger la ville des impacts du changement climatique. Par conséquent, des efforts supplémentaires sont nécessaires pour accroître les connaissances des acteurs internes au cœur de la municipalité ainsi que du public sur le thème de la vulnérabilité au climat et de l'adaptation au changement climatique.

Diverses initiatives et projets sont en place pour mobiliser et impliquer les acteurs dans les efforts visant à assurer une approche de gouvernance participative. Cependant, les résultats montrent qu'il reste difficile de mobiliser les personnes à faible revenu, car l'action climatique nécessite parfois des investissements personnels. Cela pose la question du climat et de la justice sociale.

Les résultats soulignent également l'importance d'assurer la participation des résidents à la prise de décision et aux processus de mise en œuvre afin d'accroître leur sensibilisation et d'assurer l'acceptabilité des projets proposés.

Les villes examinées montrent que le suivi et l'évaluation des mesures d'adaptation en sont encore à leur stade embryonnaire, des recherches supplémentaires sont nécessaires sur ce front. L'enjeu est triple. Premièrement, les systèmes de suivi et d'évaluation existants sont plutôt axés sur l'atténuation. S'y ajoute le fait que la notion de suivi de l'adaptation est encore floue. Deuxièmement, il n'existe toujours pas d'approche systématique du suivi et de l'évaluation de l'adaptation. Les villes étudiées ont adopté une approche qualitative pour suivre l'état d'avancement des mesures mises en œuvre. Cependant, il reste difficile d'élaborer des indicateurs quantitatifs pour évaluer l'adaptation du territoire. Troisièmement, dans certains cas, le manque de disponibilité de chiffres, de données ou d'informations à l'échelle d'une ville de taille moyenne (comme souligné dans le cas de Louvain) est un défi pour assurer le suivi et l'évaluation à l'échelle locale.

Les résultats ont montré que, malgré les incertitudes liées aux événements et aux impacts météorologiques futurs, certaines villes de taille moyenne ont développé une vision à long terme et une approche flexible de l'adaptation. Ces villes suivent les stratégies élaborées et les mesures mises en œuvre pour comprendre les défis ainsi que les facteurs de succès. Cela souligne l'importance de développer une vision, la continuité des actions et la persévérance ainsi que la capacité d'apprendre de l'expérience pour accroître la résilience du territoire au changement climatique.

Afin d'accroître les capacités d'adaptation de ces villes, les services d'urgence et les acteurs concernés sont mobilisés pour améliorer leurs mesures de réponse face aux événements climatiques attendus et inattendus, par conséquent, des systèmes d'alerte et des plans d'urgence sont développés pour répondre aux incendies de forêt, aux fortes tempêtes et aux inondations.

L'évaluation des efforts d'adaptation visant à accroître la résilience climatique urbaine est complexe, car divers facteurs influent la réponse et la résilience des villes aux événements climatiques, notamment la résilience économique, la résilience des systèmes d'infrastructures bâtis, la résilience psychologique des individus ainsi que la résilience sociale ou la capacité des citoyens locaux à faire collectivement face aux stress et à y répondre. Cette thèse développe un indice d'adaptation au climat du point de vue de la gouvernance. En d'autres termes, il considère les efforts des autorités locales en place pour accroître la résilience de leur territoire aux événements climatiques.

Le fait que la « résilience » ne soit pas une caractéristique statique augmente la complexité de la mesure ou de l'évaluation des approches de gouvernance de l'adaptation. Cela nécessite le maintien de collecte de données à jour. En outre, le manque de données à l'échelle des villes de taille moyenne et les « guichets uniques » pour la recherche liée au climat ont rendu l'accès aux données et à l'information difficile.

Cette thèse supposait que l'élaboration et la mise en œuvre de politiques d'adaptation au climat augmentaient la résilience d'une ville de taille moyenne aux événements climatiques comme point de départ d'une étude plus approfondie. Les résultats de cette étude ont montré que cela est vrai dans une certaine mesure. Nimègue présente un exemple de ville de taille moyenne qui a un système de gouvernance favorable (selon le score calculé en application de l'indice de gouvernance d'adaptation développé) tandis qu'elle n'a pas de stratégie d'adaptation proprement dite. La ville néerlandaise examinée avait plutôt développé une compréhension approfondie des impacts et des vulnérabilités, intégré des mesures d'adaptation et des approches dans les projets d'aménagement du territoire et impliqué divers acteurs du territoire dans l'adaptation au climat grâce à son approche de gouvernance participative. Alors que Rouen présente un exemple de ville qui a élaboré un plan climat air-énergie-territorial et travaille à la mise en œuvre de mesures d'adaptation (par exemple, Ecoquartier Zac Luciline), le score de la ville évaluant les efforts de gouvernance était le plus faible parmi les études de cas examinées et cela est dû à la compréhension relativement faible des impacts et des vulnérabilités, associée au manque de ressources nécessaires à la mise en œuvre des mesures et à la faible synergie entre les différents acteurs du territoire. Cela montre que le simple développement et la mise en œuvre de politiques d'adaptation ne suffisent pas à accroître la résilience climatique urbaine. Développer une compréhension des impacts et des vulnérabilités, disséminer les connaissances climatiques, impliquer et mobiliser les acteurs, assurer les ressources nécessaires à la mise en œuvre des mesures, suivre les progrès des mesures d'adaptation, comprendre les facteurs de succès et ajuster en permanence les politiques d'adaptation en place sont fondamentaux pour accroître la résilience d'une ville au changement climatique.

La thèse a également supposé que la capacité d'une ville à aborder les questions climatiques est un facteur de sa taille, du système de gouvernance en place, des priorités et de la motivation des autorités locales.

Les résultats ont montré que, en effet, les villes de taille moyenne pourraient faire face à certains défis lorsqu'elles abordent les questions d'adaptation au climat, en raison du manque de données disponibles nécessaires pour comprendre les impacts ainsi que du manque de diverses ressources nécessaires à la mise en œuvre des mesures.

Néanmoins, les villes de taille moyenne pourraient compenser les défis liés à leur taille en recherchant des financements ainsi qu'en collaborant avec des niveaux supramunicipaux et des experts du climat de la sphère universitaire et privée, tout en bénéficiant des opportunités qui pourraient se présenter en raison de chaînes de communication plus courtes permettant de créer des synergies entre divers acteurs (par exemple, la création d'une organisation à l'échelle de la ville, comme c'est le cas à Louvain). Sans compter que l'ampleur du territoire et les enjeux abordés dans les villes de taille moyenne semblent plus gérables et moins déroutants que les problèmes rencontrés par les métropoles. Les villes de Växjö et de Nimègue sont des exemples de villes européennes de taille moyenne qui ont un système de gouvernance d'adaptation favorable (selon l'index développé), prouvant que l'échelle de la ville ne l'empêche pas de prendre des mesures pour s'adapter au changement climatique. Pourtant, dans ces cas en particulier, les autorités locales jouissent d'une grande indépendance dans la prise de décision et ont la volonté politique de s'attaquer aux questions environnementales et climatiques. Alors qu'au contraire, dans le cas de Rouen avec un système de gouvernance centralisé, les niveaux supramunicipaux semblent avoir plus de « pouvoir » d'action lorsque l'adaptation doit être abordée à l'échelle locale. Cela atteste que la motivation et la volonté politique de la ville, associées à un environnement politique stable -assurant l'engagement à long terme d'une ville - semblaient être des facteurs déterminants pour accroître la capacité d'adaptation d'une ville et sa résilience climatique. Cela appelle également à donner aux autorités locales les moyens de s'attaquer aux problèmes climatiques à l'échelle locale et à garantir la disponibilité de ressources adéquates.

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La gouvernance de l'adaptation au changement climatique dans les villes moyennes en Europe. Une approche comparative : Le cas de Rouen (France), Växjö (Suède), Louvain (Belgique), Nimègue (Pays-Bas) et San Sébastian (Espagne)

En raison des impacts croissants attendus sur les villes, leurs résidents et leurs infrastructures, la question de l'adaptation des zones urbaines aux changements climatiques est un enjeu majeur. Cette recherche se concentre sur les villes européennes de taille moyenne en faisant l'hypothèse que ces villes pourraient être désavantagées par rapport aux grandes métropoles étant donné qu'elles pourraient avoir des ressources techniques, financières et humaines limitées. L'objectif du travail est donc d'analyser l'action des municipalités et des gouvernements locaux dans l'élaboration et la mise en œuvre des stratégies environnementales et des plans d'action d'adaptation. À cette fin, une approche d'étude de cas comparative est adoptée, en se concentrant sur cinq villes européennes de taille moyenne, choisies dans différents contextes nationaux : Rouen (France), Växjö (Suède), Louvain (Belgique), Nimègue (Pays-Bas) et San Sébastian (Espagne).

Les villes retenues sont distinguées (notamment par des labels) pour avoir développé et mis en œuvre des « bonnes pratiques » pour augmenter leur résilience aux changements climatiques. Il s'agit de comprendre la motivation, les moteurs, les leviers et les opportunités que les gouvernements locaux ont trouvés pour s'adapter au changement climatique. Mais également de déterminer les obstacles auxquels sont susceptibles d'être confrontées les villes qui font des efforts pour s'adapter au changement climatique.

À partir d'une prise en compte des divers aspects de l'adaptation (connaissance des impacts des changements climatiques, définition d'une stratégie, opérationnalisation, retour d'expérience...), un "indice de résilience climatique urbaine" est développé afin d'évaluer les efforts de gouvernance de l'adaptation. Cet indice est appliqué à chacune des études de cas sélectionnées pour quantifier et comparer les villes les unes par rapport aux autres.

Les résultats de la comparaison révèlent des similitudes comme l'importance de la collaboration des autorités locales avec les experts locaux et les universités pour combler les lacunes dans les connaissances en matière d'adaptation au changement climatique. Ils soulignent également l'importance de cartographier la vulnérabilité, de sensibiliser le public et d'adopter une stratégie d'anticipation des risques et d'adaptation au changement climatique au lieu de prendre des mesures réactives. L'analyse comparative souligne la nécessité d'endosser une approche de gouvernance participative, de transformer les stratégies en plans d'action et de mesures concrètes, et d'expérimenter des initiatives à petite échelle. Elle montre également des manques dans le développement de systèmes de suivi et d'évaluation ainsi que des indicateurs dédiés à l'évaluation des efforts d'adaptation. Enfin, elle souligne l'importance d'élaborer une vision à long terme ainsi que des plans de contingence pour faire face aux impacts climatiques imprévus.

Mots clés : Changement climatique, Adaptation, Gouvernance, Villes moyennes, Résilience urbaine

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