Analysis of the decision-making processes of municipal policy-makers on urban climate change adaptation for extreme precipitation

Master Thesis

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by

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Preface

Dear reader,

Before you lies my thesis that I wrote from February to July 2025 to graduate from my master Engineering and Policy Analysis of the Technical University of Delft. In this thesis, I explore the decision-making processes of municipalities in the context of urban climate change adaptation. This topic is very relevant as the impacts of climate change are becoming more clear. Extreme rainfall and heat, are both challenges for our way of living in Urban Areas. Hopefully you enjoy reading my thesis on climate change adaptation as much as I enjoyed learning about the topic and writing it.

Over the past six months, writing this thesis I have learned a lot about the topic of climate change adaptation and about my personality. I have learned valuable lessons about my way of working and about my strengths and weaknesses. writing this thesis was a very fun experience, which I enjoyed, but this would not have been possible without the help of so many people.

First I would like to thank Lisa, for providing me with extensive feedback, thoughtful suggestions, trust in my abilities and constant positivity. I would also like to thank Nihit for his sharp insights, valuable feedback and knowledge of governmental decision-making. Furthermore, I would also like to thank Kai, who always made time to answer my questions and offered helpful suggestions during our many meetings. Your knowledge on the topic and literature suggestions really helped improve the quality of my work! I also want to thank Timo for his experience from practice, his engaging discussions, trust and very helpful overviews on the white boards.

My colleagues from APPM Management Consultants also deserve a thanks for their nice talks, lunches and time they have spent on helping me and find interview participants and helping me and shape my result section.

Last but not least I want to say thank you to my family and friends that have helped me through my thesis with their encouragement, humour and continuous support in the writing process of my thesis. Your interest in my progress helped me a lot!

I hope you enjoy reading!

Suzanne Wink
Delft, July 2025

Summary

Climate change is causing more extreme weather events. To build resilience against these events, cities and urban areas must adapt. However, there is a gap in the literature on how theoretical insights and practical knowledge translate into actual decision-making in urban climate change adaptation. Understanding how decision-makers in municipalities make decisions for urban climate change adaptation, is an important missing link to achieving more effective adaptation through policy and action. To address this, the following main research question is explored:

"How do municipal level decision-makers perceive the decision-making processes around municipal climate change adaptation for extreme precipitation events and the factors that influence them?"

By answering this question, the study contributed to Sustainable Development Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable (Independent Group of Scientists, 2023). This study has provided insight into how Dutch municipalities shape climate change adaptation measures by investigating the decision-making processes of municipal decision-makers by using the Nutt (2008) phases model. This model includes five phases. The first is the "intelligence gathering" phase, where projects are initiated. Tactics in this phase include "needs" and "opportunities". The next phase is the "directions from", where possible solution paths are explored using tactics such as "idea", "objectives" or "problems". Then follows the solution found by phase, where concrete options are developed using the tactics "benchmark", "idea", "innovation", or "solicitation". These options are compared in the "evaluation" phase, using tactics such as "analysis", "judgment", and "bargaining". The final "implementation" phase involves choosing and mandating actions through tactics "edict", "persuasion", "participation", or "intervention". In addition to identifying these phases and tactics, the research also explores contextual factors and perceptions that influence decision-making throughout the process. To do so, thirteen semi-structured interviews were conducted with municipal decision-makers from various Dutch municipalities.

Decisions on climate change adaptation for extreme precipitation tend to follow a similar structure across municipalities.

The **"intelligence gathering" phase** usually starts with an "opportunity", sometimes accompanied by a "need". The "opportunity" often arises from the requirement to conduct a stress test under the Delta Program for Spatial Adaptation, an upcoming area development project, coupling climate change adaptation to other projects in the public space, or the replacement of outdated public infrastructure. The second tactic is "needs", often triggered by extreme rainfall or visible water management issues. When "needs" are urgent and clear, they tend to attract political attention and lead to faster implementation. In contrast, "opportunities" sometimes lead to delays if no urgency was felt.

In the **"directions from" phase** municipalities typically define "objectives", though the type and scope vary widely. Some aim for broad improvements like increasing greenery or maximizing climate change adaptation in a project, while others focus on technical goals. If adopted by local politics, "objectives" may gain more weight and become binding. To define "objectives" sometimes the tactic "problem" is used. Then models and maps are used to define the "problem" which are then translated into the "objectives". "Problems" can also be identified through the input of stakeholders or participation of residents.

Next, in the **"solutions found by" phase**, the solutions are identified, different tactics are employed to generate options. Some municipalities used the tactic "benchmark", where they copied successful measures from other municipalities. Other municipalities standardized their approaches by always implementing the same measures. This was often done from a maintenance and budget perspective. But also add green was sometimes standard integrated in a project. Some municipalities were "innovative" by examining the specific situation, asking what is possible within the budget, space, soil conditions

and other environmental constraints. Based on that, new solutions were developed effectively. Sometimes a consulting firm was hired to investigate innovative ideas or to explore how similar problems were solved elsewhere, this is reflected in the ”solicitation” tactic. Then ”benchmark” and ”innovation” were combined with ”solicitation”. Hiring an external party led to more convincing argumentation from the other departments of the measures. Also, sometimes the capacity of the municipality is too limited, that is why an external party is hired.

The next phase is the **”evaluation” phase**. ”Evaluation” typically involved the tactic ”benchmarking”, which reflects inter-departmental consultation, and citizen participation. ”Objectives” set earlier are checked against the proposed solutions, via the tactic ”analysis”. Often, these methods are combined: for example, through integrated planning sessions, followed by technical verification via modeling.

The final phase is the **”implementation” phase**. Here, the decision to implement a project was political, through edict. Or through negotiation between departments which was reflected in the tactic participation. Particularly the maintenance department was often important in giving a go or no go for a project. In some cases, interventions or persuasion resulted from citizen action and bottom-up signals.

Besides looking at the process and the different phases, the research also looked at the influence of contextual factors and perceptions that influence the whole decision process and no specific process phases these are: Organizational characteristics. Practical challenges, budget, Municipal policy, Participation, Municipal politics, Unclear Responsibility, Risk perception & urgency, Innovation and Maintenance abilities.

The research contributes to the literature by using the Nutt (2008) framework in a new context. It also showed that the tactics from the Nutt (2008) framework are not exclusive but can be used together. Furthermore, the research showed which context factors influence which phase of the decision-making process, and which contextual factors influence the complete process. Also differences between large, medium and small size municipalities are discovered. The most important finding is that for climate change adaptation urgency is needed, because without urgency other short-term goals will always be prioritized.

Recommendations for moving forward are that the sense of urgency must be made tangible within municipalities. Furthermore, clear roles and responsibilities should be defined in each phase of the process. Finally, municipalities can benefit from learning from each other to improve their approach and avoid reinventing the wheel.

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Nomenclature

Abbreviations

Abbreviation	Definition
CCA	Climate change adaptation
CCM	Comparative Cognitive Mapping
DPRA	Delta Programma on spatial adaptation
EOL	End of Lifetime
KPI	Key Performance Indicator
NAS	national climate change adaptation strategy
NUP	national execution programme
SDG	Sustainable development goal

1

Introduction

Human CO_2 emissions have significantly altered the global climate (IPCC, 2014). Rising temperatures increase the frequency and severity of natural hazards (Aerts et al., 2014; Kievik and Gutteling, 2011), such as pluvial floodings. Pluvial floods occur because warm air retains more moisture than cold air. Consequently, with increasing temperatures, periods of extreme precipitation are becoming more frequent (Klimaatadaptatie Nederland, n.d. KNMI, n.d.-a).

In recent years, Europe has suffered from extreme rain events. In Valencia, Spain, severe rainstorms and subsequent flooding caused the death of 62 people (Mebius, 2024). Central Europe has also experienced more intense and frequent heavy rain events (KNMI, 2024). In the Netherlands, the province of Limburg was struck by an extreme rainfall event in 2021, which led to flooding and damage. This incident raised important questions about the preparedness of the Netherlands for such extremes (Louman, 2024). Research by Deltares explored what could have happened if the same rainstorm had occurred elsewhere in the Netherlands. They concluded that the projected impacts are significant and cannot be overlooked (Klimaatadaptatie Nederland, 2022). In June 2024, the Dutch city of Enschede was struck by an extreme weather event. One year later, the consequences are still visible, and the original residents of the affected area have not yet returned to their homes (Smit, 2025). Enschede once had numerous streams running through the city, but these were closed off, causing water to collect in the lowest-lying areas. What happened in Enschede could happen anywhere in the Netherlands, because the sewage systems that have been developed over the past century are no longer equipped for the rainfall patterns of today (Smit, 2025).

From 1910 to 2022 precipitation in the Netherlands increased by more than 26%, with the number of days exceeding 50 mm of rainfall increasing by 85% since 1951 (Compendium voor de Leefomgeving, 2022). Although there are variations between years, the general trend highlights an increasing risk of pluvial flooding (KNMI, n.d.-b). With its dense population and many impermeable urban surfaces, the Netherlands is especially vulnerable to pluvial flooding (Son et al., 2023).

To reduce the risks of climate change, such as extreme rain, municipalities must implement climate change adaptation measures, particularly in urban areas. Municipalities can take measures such as redesigning sewage systems, building infiltration basins, and applying permeable pavements. Chapter 2 discusses how adaptation should be implemented and governed, including the drivers and barriers involved. Despite the abundance of scientific and practical knowledge on climate change adaptation, the implementation of measures remains limited (Biesbroek et al., 2015; Orlove et al., 2020; Siders & Pierce, 2021). There is a gap between the knowledge on climate change adaptation in the literature, the possible urban measures, the awareness of central governments, and the actual implementation.

Several explanations exist for this gap. First, little is known about the decision-making processes for climate change adaptation within municipalities (Siders & Pierce, 2021). Second, the context factors and perceptions that influence the decision-making process remains underexplored(Siders and Pierce, 2021). Third, Biesbroek et al. (2015) criticizes the “barrier thinking” approach as oversimplifying decision-making. Biesbroek et al. (2015) stresses the importance of analyzing the context more

thoroughly. There is a causal link between context, process, content, and outcomes, making context essential for studying decision-making processes (Bell et al., 1998). Based on the analysis of social-ecological systems (Ostrom, 2007) to research context, you should look at the actors, the larger context and the goals (Moser & Ekstrom, 2010). Several research have focused on perceptions on Nature Based Solutions (NBS) and climate change in general, but perceptions on climate change adaptation are not yet explored.

This master thesis investigates the decision-making processes for municipal climate change adaptation, analyzing how the decision-making processes, contextual factors, and the decision-makers' perceptions influence climate change adaptation for extreme precipitation events.

1.1. Research Questions & objectives

This research aims to study the inner workings of decision-making processes to understand how they could be adjusted to enable climate change adaptation in the Netherlands. Therefore, this research answers the following research question:

"How do municipal level decision-makers perceive the decision-making processes around municipal climate change adaptation for extreme precipitation events and the factors that influence them?"

To be able answer the main research question, two sub-questions are proposed, one focusing on the decision-making process and the other focusing on what context factors are perceived to influence the decision-making process.

Sub-question 1 is: *What is the municipal decision-making process for climate change adaptation decisions for adapting to the effects of extreme precipitation in cities?*

The objective of sub-question 1 is to identify the processes used in decision making for climate change adaptation and evaluate the performance of these processes. With unraveling the decision-making process, the goal is to understand why climate change adaptation measures are less implemented in practice (Siders & Pierce, 2021).

To answer sub-question 1, a theoretical framework based on Nutt (2008) is used. The justification for this theoretical framework is described in Chapter 4. To gather data, interviews are held with municipal decision-makers. The decision-making process tactics of the Nutt (2008) framework (see Table 4.2) are matched to the processes discussed in the interviews. As such, results outline a decision-making process map for every participant, showing the different tactics that the participants have used, this is shown in the Appendix E.

Sub-question 2 is: *What are the different perceptions and context factors that influence the decision-making process of climate change adaptation decisions for adapting to the effects of extreme precipitation events in cities?*

The objective of sub-question 2 is to determine different context factors and perceptions that have an influence on the phases of decision-making process. These context factors and perceptions help understand the dynamics and complex perspectives as described by Biesbroek et al. (2015).

The research of the perceptions is inductive and done using a hybrid version of Causal relation diagrams and Cognitive Maps, visualized in Appendix D. The maps are used to visualize which context factors and perceptions influence the decision-making process step tactics identified in sub-question 1. Cognitive maps offer a structured way to analyze the internal and external environmental influences on the process (Pluchinotta et al., 2022). Cognitive maps are often used to overcome barriers that lead to difficult decision-making problems (Hermans et al., 2018). Causal relation diagrams structurally give an overview of what factors are influencing other factors in a system. A hybrid version is used to show the impact of factors on the decision-making process tactics. Perceptions might vary per actor and context may vary per decision or municipality, as outlined in Paragraph 2.4.

1.2. Scope & definitions

Clear definitions are necessary to ensure a scoped master thesis, leading to clear goals and conclusions. First, the scope of the research is discussed in paragraph 1.2.1. Second, the definitions on climate change adaptation are discussed in Paragraph 1.2.2. Third, the definition of decision-making processes used in this research is discussed in Paragraph 1.2.3. Finally, perceptions are defined as described in paragraph 1.2.4.

1.2.1. Scope

The scope of the research is focused on Dutch urban areas. The focus is on urban areas because the impact of extreme precipitation is high cities (X.-H. Zhou et al., 2023). An Urban area is defined as: "*A grid of 500 by 500 meters is considered an urbanized area when the surrounding address density is 1 500 or more per square kilometer in the grid.*" (Statistics Netherlands, 2025). In this research an urban area concerns an inner-city area. Furthermore, The Netherlands is an example of a densely populated country with many urban areas, making Dutch municipalities a suitable geographical scope. The temporal scope concerned a period of 5 months between February and June 2025.

1.2.2. Definition Climate change adaptation for extreme precipitation

GCA (2024) defines climate change adaptation as: *"Climate adaptation means taking action to prepare for and adjust to the current and projected impacts of climate change."* These impacts include heat, drought, heavy precipitation, salt intrusion, and sea level rise (Ministerie van Infrastructuur en Milieu, 2016).

This master thesis focuses specifically on the impact of extreme precipitation events. Increasing rainfall intensity is one of the more immediate and disruptive effects of climate change (Klimaatadaptatie Nederland, n.d. KNMI, n.d.-a, n.d.-b). Droughts, heatwaves, or salt intrusion primarily affect specific sectors like agriculture or public health. While extreme rainfall causes widespread consequences: flooding, infrastructure damage, and economic disruption across entire communities. Additionally, sea level rise is a slow-moving process that allows for long-term planning. In contrast, extreme rainfall is sudden and often unpredictable, requiring rapid response and proactive planning. These characteristics make it a particularly urgent and complex challenge for municipalities.

Climate change adaptation measures include educational initiatives, economic incentives, laws and regulations, ecosystem-based strategies, and adaptation changes to the built environment and technology (Owen, 2020). Examples of practical adaptation measures include green roofs to collect rainwater (Tomazin, 2017), permeable streets to enhance groundwater recharge (Linnettewest, 2023) and the creation of wetlands (Erin, 2024) to manage water levels. In addition, green areas in cities help to discharge rainwater faster (Boogaard, 2025).

The focus of climate change adaptation in this research is on proactive measures designed to address ongoing climate change. This could be dual measures where, for example, maintenance is combined with the implementation of climate change adaptation measures. However, measures that have climate change adaptation as a positive side effect are excluded from the definition. The reason for this is that proactive measures must be consciously implemented to ensure that climate change adaptation reaches the desired level, while unintended benefits are only a welcome addition. Climate change mitigation is not included in the definition, as the focus of the research is on adaptation to unpreventable climate change, rather than preventing climate change from happening.

In addition, the focus of the measures referred to in this master thesis are those decided by local governments. This means that measures implemented by municipalities fall within this definition, while measures implemented by provinces, waterboards, and the national governments are outside of the research scope. The reason for this is that central governments primarily make strategic decisions and establish overarching frameworks, while local governments directly implement climate change adaptation measures in cities (United Nations Development Programme, 2024). Furthermore, the impacts of climate change are felt on a local level, therefore, policies should also be implemented at the local level (IPCC, 2014).

1.2.3. Definition Decision-making process

Mintzberg et al. (1976) defines a decision process as: *"a set of actions and dynamic factors that begins with the identification of a stimulus for action and ends with the specific commitment to action."* Nutt (2008) defines decision-making processes as: "*different composed steps decision makers take to eventually come to a final decision."* The definitions of Mintzberg et al. (1976) and Nutt (2008) are used in this master thesis. Furthermore, as explained in Paragraph 1.2.2, the decisions examined in this master thesis are those that are deliberately and proactively implemented by municipalities to reduce the effects of extreme precipitation events in urban areas.

1.2.4. Definition Perceptions

In this research, perceptions are defined as the way interview participants view the functioning of the system and the factors that influence it. These include subjective views, interpretations, and expectations of the participant on what influences how decision-making processes are shaped (Hermans et al., 2018; Pluchinotta et al., 2022; Van Esch & Joosen, 2015). Such perceptions provide insight into how respondents believe that contextual factors influence decisions. By exploring these perceptions, the study aims not only to identify which external factors affect decision-making, but, more importantly, to understand how people perceive and interpret these influences. This is essential for understanding the underlying dynamics of the decision-making process.

1.3. Relevance

This master thesis research is **scientifically relevant**, as it aims to contribute to explaining the gap that extensive knowledge is not translated into climate change adaptation action (Biesbroek et al., 2015; Orlove et al., 2020; Siders and Pierce, 2021). Furthermore, it increases the understanding of decision-making processes for climate change adaptation decisions and the influence of context and perceptions of municipal decision-makers involved in these processes. By providing empirical insights, the thesis contributes to the academic literature on decision-making processes within governments and around climate change adaptation. Additionally, this thesis is adding to existing theory, by applying the Nutt (2008) framework that was designed for management science, in the context of public decisions on climate change adaptation. Using the framework in this context improves the development, and limitations are shown. Furthermore, the study shows how the Nutt (2008) framework is meaningful in another context, such as governmental climate change adaptation decision making. This thesis adds to the research fields of decision science, policy analysis and climate change adaptation research.

The **societal relevance** of the research is that it will contribute to SDG 11: "Make cities and human settlements inclusive, safe, resilient and sustainable" (Independent Group of Scientists, 2023). By understanding climate change adaptation decision making for urban areas, recommendations are provided on better structuring the decision-making processes in municipalities. This will help municipalities implement more climate change adaptation measures. This will lead to a safe and well-prepared society for challenges that arise because of climate change.

This research is **policy relevant** as it examines specific decision-making tactics of climate change adaptation decision-making processes and policymakers' perceptions of this. The research investigates whether municipal decision-makers currently use tactics that are considered successful by Nutt (2008). Furthermore, by identifying perceptions and context factors, the study helps improve decision making and implementation of climate change adaptation.

1.4. Thesis outline

In Chapter 2, a literature review is performed, to gain an understanding of what has been researched on the topic so far and to find out how climate change adaptation is currently embedded in local governments. Second, the methodology is discussed in Chapter 3, here is explained how the research questions is going to be answered. Third, in Chapter 4 the theoretical framework on decision making processes is provided. Fourth, in Chapter 5 the results are provided, which are discussed in Chapter 6 along with the limitations and future research options. Finally, in Chapter 7 the conclusions, contributions to science and the recommendations for practice are provided.

2

Literature review

This chapter reviews insights from academic literature, with a focus on municipal climate change adaptation. Paragraph 2.1 explains how climate change adaptation is governed in the Netherlands. Paragraph 2.2 reviews general literature on governance modes for climate change adaptation. Then, Paragraph 2.3 explores how climate adaptation decisions are made at the local level and what frameworks exists for decision-making. Paragraph 2.4 examines the contextual factors, such as barriers, enablers, and perceptions, that shape climate change adaptation decisions. Finally, Paragraph 2.5 identifies the research gap that this thesis aims to address.

To gather literature on the topic, a systematic search was conducted, supplemented by literature shared by the research team and additional sources identified through snowballing. A full explanation of the literature search process is included in Appendix A.

2.1. Climate change adaptation governing structures in the Netherlands

This master's thesis focuses on the Netherlands, as explained in Paragraph 1.2.1. To understand the results and what they mean, it is important to know how the Dutch government works and how climate adaptation policies are made in the Netherlands. This paragraph gives an overview of the structure of the Dutch government and the main policies that influence climate adaptation.

The Delta Program is a Dutch government initiative designed to protect the country from water-related risks. It was created after the 1953 North Sea flood, which claimed 1,836 lives (Zeeuws-Archief, n.d.). The program is updated every year and is carried out by the Delta Commissioner. The Delta Commissioner works independent from the national government. The Delta commission has a fixed budget that cannot be cut. The main goals of the Delta Program are flood protection, reliable freshwater supply, and making the country climate resilient (Ministerie van Infrastructuur en Waterstaat, 2024). The third goal, creating a climate-resilient country, matches the focus of this thesis. It means that cities and regions adapt to climate change by creating spatial solutions, such as water storage areas and green infrastructure. On climate change adaptation the Delta program has seven ambitions that municipalities should execute (Kennisportaal klimaatadaptatie, n.d.; Ministerie van Infrastructuur en Milieu, 2016), these are:

1. Beware of vulnerabilities.
2. Talk about risks and find strategies.
3. Create an implementation agenda.
4. Use opportunities for synergy.
5. Stimulate and facilitate.
6. Regulate and safeguard.

7. Act in case of emergency.

The Delta Program is carried out in cooperation with water boards, provinces, municipalities, and the national government. All levels of government have agreed on the goal of making the Netherlands climate adaptive by 2050 (Kennisportaal Klimaatadaptatie Nederland, 2025). Each has its own responsibilities in achieving this goal.

The highest-level government is the national government or the central government. The central government consists of the King, the ministers and the States General, which comprises the House of Representatives (Second Chamber) and the Senate (First Chamber) (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2025). The national government is responsible for national policy, public finances, foreign affairs, and internal affairs and consists of different departments. These departments and ministers are responsible for different subjects. The Second Chamber is responsible for monitoring ministries, by proposing, amending, and approving legislation, as well as keeping the government accountable (Tweede Kamer der Staten-Generaal, n.d.). The First Chamber reviews the proposed legislation (Eerste Kamer der Staten-Generaal, n.d.).

The central government on behalf of the Ministry of Infrastructure and Water Management and in collaboration with the ministries of ”Housing and Spatial Planning”, ”Climate and Green Growth”, ”Economic Affairs”, ”Justice and Security”, ”Agriculture, Fisheries, Food Security and Nature”, ”Education, Culture and Science”, ”Social Affairs and Employment”, and ”Health, Welfare and Sport” have presented the national climate change adaptation strategy (NAS), published in 2016. After evaluation in 2023, it was concluded that the NAS should be sped up, which led to the National Execution program (NUP) in 2023, visualized in Figure 2.1. The NUP states that access to knowledge should be increased, climate change adaptation should always be included in policy and execution and climate change adaptation should be inclusive. Focus areas are water, agriculture, human culture, living and working. As explained in Paragraph 1.2.2, the focus of the thesis is on urban climate change adaptation. Living and working goals apply to this: every newly built house should be green and climate adaptive, everyone should live in a climate adaptive home, employment should be in a green and healthy environment and infrastructure should be strong and resilient (Klimaatadaptatie, n.d.). In 2026 a new NAS will be published.

The tier of governance that is one level more decentralized than the national government, are the provinces. The Netherlands is divided into 12 provinces, which are intermediaries between the national government and municipalities (Figure 2.2). The governance of the province consists of a Provincial Council, an Executive Council, and a King’s Commissioner, who represents the national government.

Their main responsibilities include spatial planning, nature conservation, regional economic development, and the oversight of municipalities and water boards (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.). For climate change adaptation, the main responsibility is addressing the spatial challenges of the Netherlands (Climate Adaptation Knowledge Portal Netherlands, 2025). Climate change adaptation should be integrated within these challenges. Spatial issues involving climate change adaptation include housing construction, sustainable offices, spatial planning, energy transition, vital rural areas, regional climate-resilient accessibility, and making vital infrastructure climate adaptive (Climate Adaptation Knowledge Portal Netherlands, 2025). The main role of the provinces is to collaborate with other levels of governance. At the same time, they should set a good example by ensuring that their own assets are climate-adaptive (Climate Adaptation Knowledge Portal Netherlands, 2025).

One level more decentralized than the provinces are the waterboards. Waterboards are a unique form of governance in the Netherlands, dating back to the Middle Ages. Each water board has a General Board (elected and appointed members), an Executive Board, and a Dijkgraaf (chairperson, similar to a mayor). Their core tasks include flood control, water quality, water level management, and wastewater treatment. Waterboards mainly play an advisory role in urban climate change adaptation (Ministerie van Infrastructuur en Milieu, 2016). Since they are responsible for managing certain waterways within urban areas, they can, in some cases, also impose objectives on municipalities.

Municipalities are the most decentralized level of governance in the Netherlands. They are the closest to citizens. There are more than 340 municipalities in the Netherlands. Each municipality has a municipal council, a board of mayor and aldermen, and a mayor, who is not elected democratically but appointed. Municipalities are responsible for services such as education, youth care, social welfare,

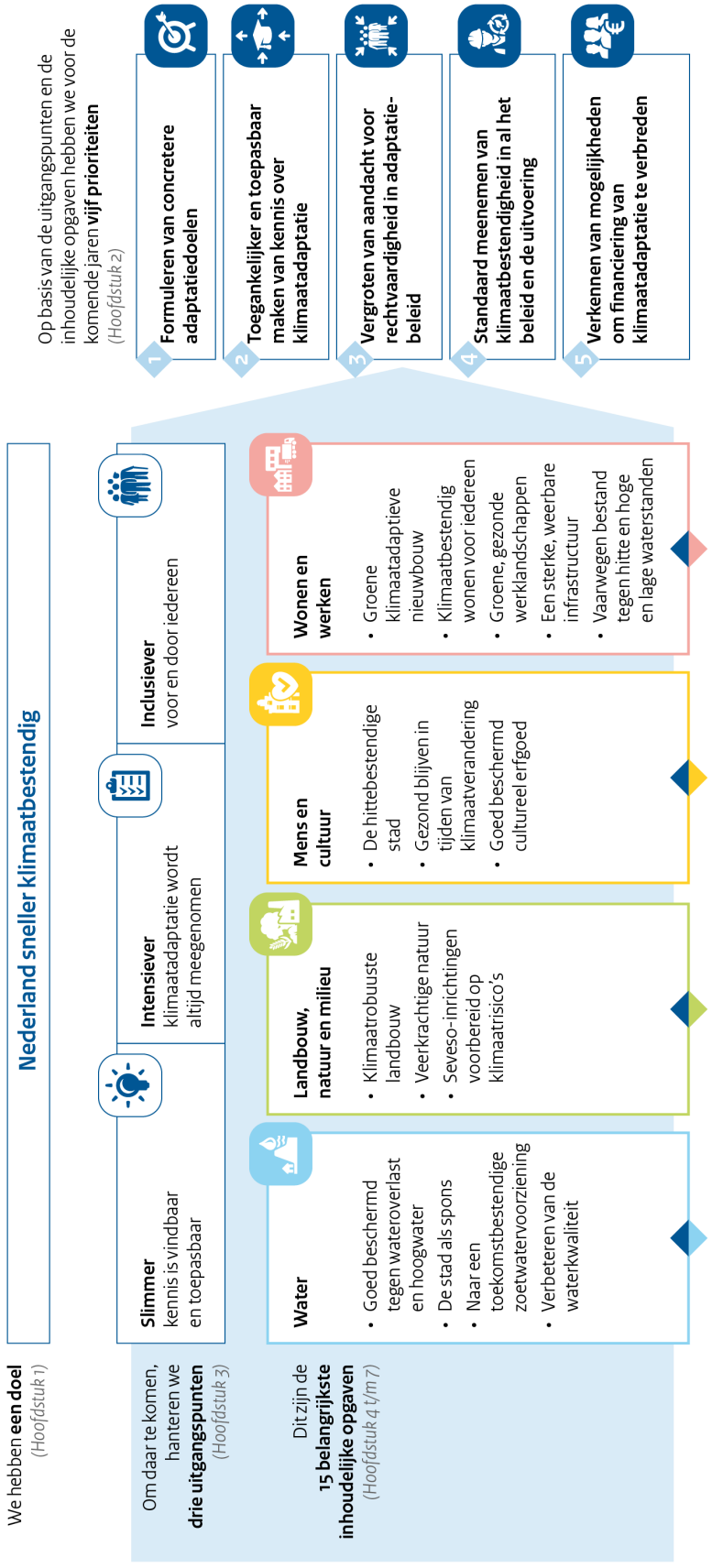

Figure 2.1: Nationaal uitvoeringsprogramma 2023, to speed up the NAS (Klimaatadaptatie, n.d.)

Figure 2.2: Provinces of the Netherlands (Wikipedia contributors, 2024)

zoning and building regulations, and local public safety (VNG, 2025). For climate change adaptation, municipalities are responsible for implementing climate change adaptation within the borders of their municipality.

Important to note is that residents in the Netherlands have the right to participate in municipal plans. Participation increases support for municipal policy plans and measures (Wij zijn Spectrum, 2024). Participation could emerge by informing, discussing, or designing. In the Netherlands, this is based on the ladder of participation which consists of different types: to inform, to consult, to dialogue, to co-produce, or to co-decide on the municipal plans (Wij zijn Spectrum, 2024). Municipalities can decide which level of participation is manageable and desirable.

Based on the Delta Program all municipalities are required to perform stress tests with a benchmark rainfall of a situation that might happen once in 100 years. This helps municipalities to see where the risks are and what the current performance is of different areas in the municipality. Furthermore, the National Climate Indicator for a Green, Climate-Adaptive, and Built Environment (shown in Figure 2.3) was developed for municipalities to define goals and objectives for climate change adaptation (Kennisportaal Klimaatadaptatie Nederland, 2023).

Based on this indicator and stress tests, most municipalities develop their municipal plans on climate change adaptation. For example, ”The Hague, wegwijzer klimaatadaptatie” (van Tongeren et al., 2025) explains a step-by-step approach to climate change adaptation in The Hague. This entails that first, the local situation should be examined, using stress tests and experts within the municipality. Second, The Hague ambitions and requirements should be examined. Third, measures should be found and designed according to the local situation. Finally, the plan must show that it takes into account The Hague’s ambitions and requirements.

Within municipalities, advisory civil servants are often responsible for the implementation of climate change adaptation. They decide where and how climate adaptation measures should be implemented in projects and area redevelopments. There are big differences between municipalities on how they perform in implementing climate change adaptation measures (van Bijsterveldt et al., 2021). The implementation agendas differ a lot between municipalities and municipalities find different barriers to execute climate change adaptation (van Bijsterveldt et al., 2021).

Figure 2.3: The National Climate Indicator for a Green, Climate-Adaptive, and Built Environment (Kennisportaal Klimaatadaptatie Nederland, 2023)

2.2. Governance modes on the municipal level

In the Netherlands, climate change adaptation receives a lot of attention from municipalities. Several academic studies focus on how the municipalities should be structured to facilitate climate change adaptation. These studies focus on the governance modes and municipal structure that help facilitate adaptation.

A major obstacle found in the literature on climate change adaptation governance is the misalignment of policies both within and between different levels of government that leads to fewer climate change adaptation decisions (Oulahen et al., 2018). This can be explained by the fact that traditional governance approaches based on “predict and plan” have been proven inadequate to make effective decisions about climate change adaptation (Quay, 2010). Furthermore, there are different views among stakeholders on how adaptation should be governed, which leads to a fragmented approach. This lack of consensus can hinder coherent and coordinated adaptation strategies (Molenveld et al., 2020). Therefore, a change in the decision-making processes is necessary (Braams, 2023).

Integrating climate change adaptation into municipal planning is a first step in this direction (van Bijsterveldt et al., 2021). Furthermore, governance frameworks should include support for local governments to implement more climate change adaptation measures (Schoenefeld et al., 2023). A framework such as multi-level governance can support effective climate change adaptation by distributing responsibility across different levels of the government (Amundsen et al., 2010). In this approach, national governments set priorities and allocate resources, while local governments handle implementation. Another promising framework is transformative governance, which includes a proactive and strategic role for governments in driving sustainable transitions (Braams, 2023). Rather than reacting to change, a transformative government actively guides adaptation efforts and fosters innovation. Successful climate change adaptation is only implemented in situations where governance provides space for collaboration (Van Buuren et al., 2015). Furthermore, collaborative decision-making processes lead to more successful climate change adaptation (Owen, 2020). Collaborative decision-making involves a wide range of stakeholders, such as government agencies, communities, and organizations. These organizations should work together to develop and implement strategies. Incorporating diverse perspectives and local knowledge not only strengthens public support, but also improves the overall quality of decisions (Biesbroek et al., 2015; Fatti & Vogel, 2011; Preston et al., 2015). In addition, small incremental steps are supposed to be more effective than large transformations (Termeer et al., 2016). An approach of continuous change should be adopted, where small steps can lead to large progress (Termeer et al., 2016).

2.3. Decision-making models in the context of climate adaptation

Although the need for adaptation is widely acknowledged and frameworks and measures are proposed, the decision-making processes behind their implementation remain complex (Siders & Pierce, 2021). Adaptation involves multiple stakeholders and is shaped by uncertainty, competing interests, interdependencies between actors, and shifting goals (Head, 2018; Rittel & Webber, 1973). To better understand how municipalities navigate these complexities, the next section reviews the literature on decision-making processes developed for climate change adaptation.

Researchers approach the study of decision making from different perspectives (Nutt, 2011). The first approach is to focus on the philosophy of science to develop prescriptive models. Prescriptive models describe how decisions should be made (Daft, 1995; Nutt, 1989, 2011; Perrow, 1967; Simon, 1977; Thompson, 1967). The second approach is to focus on hybrid options. Hybrid options integrate procedures to identify underlying processes (Havelock, 1973; Nutt, 2004, 2011). The third approach is to focus on how decision-makers behave. This option uses observations, interviews, and surveys to uncover practical decision-making procedures (Dean and Sharfman, 1996; Mintzberg et al., 1976; Nutt, 1984, 2008, 2011).

Interestingly, decision-making frameworks often become self-fulfilling (Nutt, 2011). When decision making is studied as a step-by-step process of an individual, the decision-making that is found shows micro-level dynamics. In contrast, when decision-making is studied with a political perspective, the decision-making process that is found, shows meso- and macro-level dynamics (M. Harrison & Phillips, 1991). The chosen framework shapes how decision-making is interpreted, with no single approach

being definitively better than the other.

At the micro-level, decision making can be analyzed through cognitive psychology. According to cognitive psychology, different types of decisions can be made in response to climate change, often distinguishing between System 1 and System 2 (Orlove et al., 2020). System 1 decisions are intuitive and made quickly, while System 2 decisions involve analytical thinking (Orlove et al., 2020). For individuals in a private context, climate-related decisions are often based on System 1 thinking. However, for individuals in a public context, climate-related decisions are often based on a combination of both System 1 and System 2 (Orlove et al., 2020). Siders and Pierce (2021) found three main decision-making strategies for decision-makers, which can be categorized as system 1, system 2 and a combination of both.

The first decision-making strategy described by Siders and Pierce (2021) is the universal optimum choice. The Universal optimum choice is associated with rational decision-making. This strategy reflects system 2 thinking. Much research has focused on developing prescriptive decision-making approaches that aim to identify the best option for climate change adaptation. Examples of prescriptive approaches are idealized rational planning (Siders & Pierce, 2021), risk analyses (Halsnæs & Kaspersen, 2018; Kvitsjøen et al., 2021; Reinwald et al., 2024; Siders & Pierce, 2021), cost-benefit analyses (Dittrich et al., 2019; Hallegatte, 2011; Q. Zhou et al., 2012) and multi-criteria decision analyses (Arabameri et al., 2019; Brito & Evers, 2016; Maanan et al., 2018). However, in practice, most adaptation decisions are made without using such models (Orlove et al., 2020), as they often require significant time and resources, while offering limited support in real-world adaptation processes (Siders & Pierce, 2021). Furthermore, when these approaches are used, they are not always feasible or effective, as high levels of uncertainty often make rational decision-making difficult (Katsikopoulos et al., 2018; Loucks, 2020).

The second decision-making strategy described by Siders and Pierce (2021) is ecological rationality. Ecological rationality is people using simple heuristics to make effective decisions in complex and uncertain environments (Luan et al., 2019; Todd and Brighton, 2016). Ecological rationality is a combination of system 1 and system 2 decisions. Many heuristics are described and developed, that are supposed to help facilitate climate change adaptation. However, the effectiveness of these heuristics in facilitating climate change adaptation remains limited (Preston et al., 2015). An explanation for this, is that many of these heuristics have not been tested on their robustness. Therefore, using heuristics does not improve the quality of the decision (Preston et al., 2015). Furthermore, the use of ecological rationality leads to difficulties in determining which contextual factors should be considered when choosing a heuristic (Schurz and Thorn, 2016). To mitigate this, suggestions are made for strategy selections (Katsikopoulos et al., 2018; Schurz and Thorn, 2016).

The third decision-making strategy described by Siders and Pierce (2021) is that there is no optimal way to choose the best decision-making process for climate change adaptation (Head, 2018; Rittel and Webber, 1973; Schurz and Thorn, 2016). This strategy mainly involves system 1, where people adjust their strategies through experience and learning (Rieskamp and Otto, 2006; Schurz and Thorn, 2016). However, in the context of climate change adaptation, this is challenging, as the effectiveness of decisions often only becomes apparent in the future (Berrang-Ford et al., 2019).

Beyond individual cognition, decision-making can also be viewed as an organizational or political process. A distinction is often made between models that follow a step-by-step, structured approach to decision-making and models that emphasize political dynamics and seizing opportunities as they arise. Both types of models are relevant, as they reflect different dimensions of real-world climate adaptation decision processes.

When decision-making is viewed as a structured, step-by-step process, a series of general phases that an individual decision-maker goes through is identified. An example is intelligence, design, choice, and implementation phases (Enserink et al., 2022; Simon, 1977). These phases reflect logical progression from identifying a problem and generating possible solutions to selecting the best option and putting it into practice. Although the terminology used may differ between studies, the underlying structure remains similar in all these step-by-step models (Scholten & Oomens, 2024). Comparable models using different labels for each phase are E. F. Harrison (1996), Keeney (2004), Lang et al. (1978), Lunenburg (2010), and Nutt (2008). This consistency suggests that a stepwise view of decision-making

continues to offer a useful lens for understanding how individual decisions are made.

Contrasting this, frameworks that emphasize political dynamics, highlight complexity, political influences, and opportunity events in decision-making. They see decision-making as an unstructured process. The dynamics of this are conceptualized in the 'Garbage Can Model' (Cohen et al., 1972), the 'Multiple Streams Framework' (Kingdon, 1984), and the 'Rounds Model' (Teisman, 2000). These models and frameworks focus on decision-making within or between governments.

The Multiple Streams Framework explains how policy change becomes possible when problems, policy, and political streams converge. Process-oriented decision-making models at the individual level clarify how the micro level actors structure their decision-making within such a policy window. Institutional dynamics and political timing are important factors, adaptation is often only considered when a policy window opens, rather than being proactively pursued (Baack et al., 2024). However, the decision-making process within such a policy window remains underexplored.

Although many frameworks describe how decisions are made, another approach is to assess the quality of the decision. In the private sector, economic indicators can help evaluate decisions, but public organizations that do not see profit as their main goal must develop their own success criteria (Siders and Pierce, 2021). Decision quality can be determined by six requirements, these are an appropriate frame, including purpose, scope and perspective, creative alternatives, clear values and trade-offs, relevant and reliable information, sound reasoning and finally commitment to action (Spetzler et al., 2016). Across all decision-making processes, context plays a crucial role. Both internal and external factors influence decision results (Bell et al., 1998; Perrow, 1967; Thompson, 1967).

In short, decision-making related to climate change adaptation is complex and multilayered. From cognitive models to political frameworks, all approaches capture a piece of the decision-making puzzle. Different models provide complementary insights, depending on whether the focus is on individuals, organizations, or systems.

2.4. Influences of context factors and perceptions

For climate change adaptation, the personal experience of decision makers and the context in which the decision is made are important aspects of the decision-making process (Orlove et al., 2020; Rieskamp and Otto, 2006; Schurz and Thorn, 2016). In explaining the implementation of climate change adaptation, many papers identify barriers and drivers. Barriers and drivers are defined by Simonet and Leseur (2019) as: *"drivers as factors and conditions that obstruct/stimulate collective (social, political, economic) abilities and efforts to reorganize (practices), restructure (institutions) or reconure (territories) the local system (human and natural) to current and future impacts (direct and indirect) of climate change. In this definition, drivers may be seen as the opposite of barriers and include cultural and cognitive aspects."*

One of the main categories of barriers to climate change adaptation lies in institutional complexity and the lack of collaboration between different levels of the government. Poor coordination and fragmentation among government agencies are frequently mentioned challenges (Azhoni et al., 2017; Biesbroek, 2014; Oulahen et al., 2018; van Heerden & van Vuuren, 2022), as well as unclear responsibilities and complex governance structures (Schoenefeld et al., 2023). Governments also often face limited institutional capacity due to a limited financial resources, human capacity, and specific knowledge (Schoenefeld et al., 2023; Simonet & Leseur, 2019; Temby et al., 2016). The High turnover of civil servants further reduces continuity and institutional memory (Moser & Ekstrom, 2010). Public awareness and participation in local communities tend to be low, limiting the acceptance and success of adaptation initiatives (Azhoni et al., 2017; Dilling et al., 2017; Oulahen et al., 2018; Roders & Straub, 2015). At the national level, overarching plans often show limited progress, further lowering local climate change adaptation implementation (Biesbroek, 2014; Moser & Ekstrom, 2010; van Heerden & van Vuuren, 2022).

Political factors form a second important barrier. There is often a lack of political leadership and urgency to address climate adaptation (Dilling et al., 2017; Oulahen et al., 2018; Simonet & Leseur, 2019). The Misalignment between and within governmental bodies undermines the coherency of policy (Biesbroek, 2014; Oulahen et al., 2018). National and municipal plans often conflict or fail to align,

leading to inefficiencies in implementation (Araos et al., 2017). Additionally, climate adaptation often clashes with short-term political interests, as its benefits are long-term and are not immediately visible to stakeholders (Simonet & Leseur, 2019). Political actors tend to prioritize visible short-term successes over abstract long-term resilience goals.

Finally, knowledge-related challenges significantly hinder adaptation efforts. Scientific uncertainty remains high, which complicates efforts to make evidence-based decisions (Wilby & Dessai, 2010). Scientific language and complexity may make research inaccessible to local officials, who often lack the necessary expertise (Simonet & Leseur, 2019; Temby et al., 2016). Conflicting definitions of adaptation in IPCC reports further contribute to confusion (Pielke et al., 2007; Simonet & Leseur, 2019). Even when useful information exists, it is often difficult to access or the data is poorly cleaned (Azhoni et al., 2017). Many decisions rely on climate models, which are not always available at the municipal level or suitable to give robust information (Simonet & Leseur, 2019). As a result, policies are often implemented without being properly tested (van Heerden & van Vuuren, 2022).

In addition to barriers, several enablers have been identified that facilitate the integration and implementation of climate change adaptation at the municipal level. First, a clear and coherent governance structure is essential to enable effective adaptation efforts (Schoenefeld et al., 2023). Local governments play a key role and climate change adaptation must be implemented structurally within local policies (Schoenefeld et al., 2023). Furthermore, the effectiveness of climate change adaptation is increased when policy measures are specifically decided for local contexts (Schoenefeld et al., 2023). Context-specific approaches allow for more targeted and relevant interventions (Schoenefeld et al., 2023).

In practice, informal understandings of roles and responsibilities between stakeholders can improve collaboration, which, in turn, supports adaptive outcomes (Schoenefeld et al., 2023; Trell & van Geet, 2019). Political leadership is also a key enabling factor; committed leaders can stimulate action and prioritize climate adaptation on policy agendas (Roberts, 2008). To move from intention to implementation, adaptation should be structurally integrated into municipal plans and embedded standard in decision-making processes (Dilling et al., 2017; Roberts, 2008).

The availability and allocation of resources also remains an important enabler for climate change adaptation. Clear assignment of human and financial resources increases capacity and increases the likelihood of sustained implementation (Dilling et al., 2017; Oulahen et al., 2018; Roberts, 2008; Schoenefeld et al., 2023). Moreover, local awareness, risk assessments, and forward-looking planning are essential to prepare for and respond to climate impacts effectively (Fatti & Vogel, 2011).

Additional enablers include tools for evaluation and financial support. The use of key performance indicators (KPI's) can help municipalities assess the effectiveness of their adaptation strategies (Díaz et al., 2024). Finally, external financing remains a vital component, especially for municipalities with limited internal resources (Dilling et al., 2017). Since context factors and personal experiences vary between municipalities, climate change adaptation decisions should be tailored to the specific local context in which they are implemented (Roders and Straub, 2015; Schoenefeld et al., 2023). Therefore, when researching decision-making processes, it is important to also consider contextual factors.

In addition to barriers and enabler, the way decision-makers perceive climate change plays an important role in the implementation of adaptation policies. Both personal beliefs and institutional culture can influence whether adaptation is pursued or avoided (Simonet & Leseur, 2019). Although few studies explicitly focus on perceptions of climate change adaptation, research on related topics such as Nature-Based Solutions (NBS) and general climate change attitudes provides insight into how these perceptions shape action.

A perceptional barrier arises from how people understand climate change itself. Skepticism or denial of climate change remains a significant obstacle, as is the tendency to downplay the impacts of climate change (Lorenzoni et al., 2007; Norgaard, 2006; Simonet & Leseur, 2019; van Heerden & van Vuuren, 2022). Furthermore, perception of risk is important. The degree to which decision-makers believe they are exposed to climate hazards, and their expectations of potential damage to people, housing, and infrastructure, directly affect their willingness to act (Lindell & Perry, 2011; Wolf et al., 2021). Often, measures are only introduced after extreme weather events, which function as wake-up calls (Amundsen et al., 2010). In Copenhagen, for example, flooding spurred the development of climate change

adaptation strategies (Arnbjerg-Nielsen et al., 2015; Madsen et al., 2019). However, even in the absence of direct experience, a strong perception of risk can be enough to motivate action (Dilling et al., 2017).

Finally, The beliefs of decision-makers about how to respond to climate risks also influence adaptation efforts. These include perceptions of how effective the proposed measures will be and their confidence in their own or their institution's ability to carry them out (Grothmann & Reusswig, 2006). In addition, their assumptions about the financial, social, or operational costs of implementation are of influence (Lindell & Perry, 2011; Wolf et al., 2021). In contrast, when climate change adaptation is perceived to lead to added value, such as improving biodiversity or enhancing ecosystem services, it can be a strong motivator for action.

In conclusion, the broader context where climate change adaptation takes place plays a significant role in shaping decisions. Although how they influence the decision-making process exactly is not yet researched. A causal relation between context, process, content, and outcomes is proven to exist (Bell et al., 1998). The context is therefore important to keep in mind when researching the decision-making process. Suggested is, based on the analysis of social-ecological systems, to research context, you should look at the actors, the larger context and the goals or objections they have (Moser & Ekstrom, 2010; Ostrom, 2007).

2.5. Research gap

Climate change adaptation plans exist at every level of the Dutch government. Every government tier has adopted the goal of being climate adaptive by 2050. However, the implementation of climate change adaptation measures in urban areas takes place at the municipal level. Research shows that effective climate change adaptation depends on a suitable mode of governance. This requires greater collaboration, the integration of adaptation into municipal planning, and stronger support for local governments (Baack et al., 2024; Molenveld et al., 2020; Oulahen et al., 2018; Owen, 2020; Van Buuren et al., 2015). To achieve this, scholars suggest moving away from the traditional "predict and plan" approach toward multilevel governance or transformative governance frameworks (Amundsen et al., 2010; Braams, 2023; Schoenefeld et al., 2023).

Other literature is researching climate change adaptation by looking at barriers and enablers for climate change adaptation. However, this "barrier thinking" approach is also criticized as it oversimplifies decision-making processes (Biesbroek et al., 2015). Research should adopt a more dynamic and complex perspective on decision-making processes (Biesbroek et al., 2015). This critique is also present in other studies that highlight the limited success of theoretical frameworks in informing real-world adaptation (Orlove et al., 2020; van Bijsterveldt et al., 2021).

The insights of the literature are rarely applied effectively in practice (Biesbroek et al., 2015; Orlove et al., 2020; Siders & Pierce, 2021; van Bijsterveldt et al., 2021). This indicates a gap between theory and implementation. This gap could be explained by the fact that little is known about the decision-making processes used for climate change adaptation measures (Siders & Pierce, 2021). More research should be done on the decision-making processes of governments, as this might explain why in practice the climate change adaptation decision-making remains limited.

The literature on decision-making offers a wide range of models across the micro-, meso-, and macro-levels, which can be used at the same time to explain another piece of the puzzle (Nutt, 2011; Simon, 1977). At the micro level, models often distinguish between System 1 (intuitive) and System 2 (deliberate thinking), which relate to the psychological and cognitive strategies individual decision-makers use (Orlove et al., 2020; Siders & Pierce, 2021). However, in practice the rational models are rarely followed. Heuristics, while commonly used, offer limited support for climate change adaptation (Preston et al., 2015; Siders & Pierce, 2021). Learning-by-doing is also difficult in this context, since the effects of adaptation measures often become visible far in the future (Orlove et al., 2020; Siders & Pierce, 2021). Decision-making literature focusing on meso- and macro-level decisions, offers a wide range of models. A distinction is made between models that follow a step-by-step approach and those that emphasize political dynamics and seizing opportunities. The political dynamics and seizing opportunities models have been used to explain climate change adaptation in the Netherlands. These show that adaptation is only considered when a policy window opens (Baack et al., 2024). The step-by-step

process frameworks have not yet been used to explain climate change adaptation decisions.

Furthermore, perceptions of decision-makers have not yet been specifically researched for climate change adaptation; existing studies on perceptions focus either on climate change in general or specifically on Nature-Based Solutions (**<empty citation>**). There is a gap in the literature on how these perceptions influence the decision-making process about concrete adaptation measures.

A gap can be identified in understanding how governments make decisions about climate change adaptation for extreme precipitation, what processes are involved, and what perceptions of the involved decision-makers and the context are in these processes. That is why this master thesis research investigates the steps of the decision-making processes. Instead of identifying this process, the aim is to also uncover the implicit structures that influence how decisions are made in practice. By doing so, an important piece of the puzzle on understanding why theoretical knowledge so far fails to translate into real-world action will be provided.

3

Methodology

This chapter outlines the methodology of the thesis. In Paragraph 3.1, the research design is discussed. Then, in Paragraph 3.2, the methodology for the development of the theoretical framework is explained and linked to the interview design. Then in Paragraph 3.3 the participant selection strategy and criteria are discussed. Furthermore, in Paragraph 3.4, the process of data collection is discussed. Next, in Paragraph 3.5, the data analyses process is discussed. The tools and computer programs that have been used are discussed in Paragraph 3.6 and in Paragraph 3.7, the ethical considerations of the research are discussed. Finally, the validity of the acquired interview data is discussed in Paragraph 3.8.

3.1. Research Design

As outlined in Paragraph 1.1, this research addresses the main question: ***"How do municipal level decision-makers perceive the decision-making processes around municipal climate change adaptation for extreme precipitation events and the factors that influence them?"*** To answer this question, two sub-questions were proposed. Both sub-questions were answered by analyzing interview data. The research approach combined inductive and deductive elements.

Sub-question 1 aimed to analyze decision-making processes within a theoretical framework, rather than developing entirely new theories. The data for sub-question 1 were collected and analyzed based on the theoretical framework described in Chapter 4. Therefore, this sub-question followed a theory-informed and deductive approach (Bhattacherjee, 2012). The research applied the Nutt (2008) framework to categorize and interpret interview data gathered from municipal policymakers, thereby employing an established framework in a new context.

Sub-question 2 involved researching the perceptions of municipal decision-makers on the influences of the context factors on the decision-making process. Sub-question 2 represents the inductive part of the research. To answer sub-question 2 codes were created iteratively through the analyzing process, explained in detail in Paragraph 3.5

The data collection for the research was entirely qualitative. Different case studies were used to reflect on decisions that have been made in Dutch municipalities on urban climate change adaptation measures for extreme precipitation events. Data was collected through semi-structured interviews. The research was carried out over 21 weeks from February until July 2025 with a cross-sectional time horizon.

3.2. Methodology for the development of the theoretical framework

The theoretical framework ensured alignment between the literature, the research design and the data collection process. The methodology for the theoretical framework design is discussed in this paragraph. The theoretical framework is outlined in Chapter 4. Using an existing decision-making framework improves the quality and validity of the results, helps to structure the findings and ensures that

the research is grounded in a solid academic foundation.

To effectively address sub-question 1 an additional literature review on decision-making processes was conducted to ensure that the chosen framework was the most suitable for researching the decision-making process. The identified literature on decision-making served as the foundation. Within this a particular focus was on articles related to Nutt (2008) or decision-making processes. Forward and backward snowballing was applied to the already identified literature. A risk was that relevant literature might have been absent from citation networks or located within a different academic niche. To account for this, a preliminary exploration scan was carried out to identify decision-making literature. Here, papers on psychological decision-making frameworks were found. These psychological frameworks were also added to the review.

The theoretical concepts discovered in the literature review are visualized in a theoretical framework for sub-question 1 shown in Figure 4.4. A complete theoretical framework of sub-question 1 and sub-question 2, is provided in Figure 4.5. In this variant, the concepts and perceptions that are researched in sub-question 2 are linked to the framework based on sub-question 1.

This theoretical framework was used as the basis for the design of the interview guide, which ensured that the qualitative data collected aligned with the theoretical assumptions of Nutt (2008) and the way perceptions have an influence are considered. The theoretical framework used for sub-question 1 was translated into codes (shown in Table 3.3), which were used to analyze the interview data.

3.3. Participant selection

To be able to answer sub-question 1 and 2 interview participants were carefully selected. This ensured that relevant and useful information were gathered. The interview participants for sub-question 1 and 2 were the same, and the data was gathered at the same time.

Participants had to meet specific criteria to fall within the scope of this research (see Table 3.1). They were required to be directly involved in decision-making on climate change adaptation, particularly in projects aimed at reducing the impact of extreme rainfall in urban areas. Each participant played an active role in the implementation of strategies and measures that help municipalities cope with heavy precipitation.

To ensure a broad and representative sample, participants were selected from municipalities varying in size, population, and urban characteristics. This diversity increased the applicability of the findings across different urban contexts. Recruitment continued until no new insights emerged from the interviews, indicating that coding saturation had been achieved.

Participants were identified and contacted through APPM, a consultancy specializing in public sector projects. APPM employees suggested contacts from their network, who were then approached via email or phone. In addition, a snowball sampling strategy was used: initial interviewees were asked to recommend other relevant experts. All participation was voluntary.

Interviews were conducted in Dutch, either online or in person, depending on the participant's preference. Each interview took approximately 45 minutes. Permission was requested in advance to record the interviews. The transcriptions were automatically generated and were then carefully reviewed and manually corrected to reduce errors. Once finalized, the transcripts were sent to participants for approval. In a few cases, participants requested that specific remarks be removed.

Table 3.1: Selection criteria for participants

Selection Criteria Participants:
Involved in decision-making
Employed at municipality or other institution that is involved in municipal decision-making
Extreme precipitation events
Urban context

In Table 3.2, the characteristics of the interview participants are discussed. Thirteen different professionals were interviewed. The first column described the number given to the participants. The second

column states whether the interview was held online or in person. The third column shows the type of organization the participant was employed. Notable is that three non-municipalities were interviewed. Of these, Participant 1 and 8 worked with many municipalities in the projects so they could describe a single interesting project they had done. From these a process could be extracted. Participant 13 was employed in a water board. These insights were used for context factors and perceptions, but no process could be extracted as this participant was not involved in projects. The fourth column discusses the size of the municipality. Small municipalities have <50.000 residents, medium sized municipalities have >50.000 and <100.000 residents and large size municipalities have >100.000 residents. Notable is that Participant 2 represented a large and small municipality. The participant had roles in the large and small municipality and these roles were discussed during the interviews and the decision-making processes corresponding to the large and small municipality were both identified. Therefore, this interview is split into participant 2A (large municipality) and participant 2B (small municipality). The fifth column shows the province of the municipality. Notable is that not every province of the Netherlands was represented in the interviews; Limburg, Groningen, Drenthe, and Friesland are missing. These provinces have primarily rural areas. This thesis focused on urban areas; therefore, it is acceptable that these provinces are not represented.

Table 3.2: Interview participants

Participant	Online?	Organization	municipality size?	Province
Participant 1	No	Urban Designer	Multiple municipalities	Multiple provinces
Participant 2	Yes	Municipality	Large & Small	South Holland
Participant 3	Yes	Municipality	Large	South Holland
Participant 4	No	Municipality	Large	North Brabant
Participant 5	No	Municipality	Large	Gelderland
Participant 6	No	Municipality	Small	South Holland
Participant 7	No	Municipality	Medium	South Holland
Participant 8	Yes	Engineering firm	Multiple municipalities	Multiple provinces
Participant 9	No	Municipality	Large	North Holland
Participant 10	Yes	Municipality	Medium	Zeeland
Participant 11	No	Municipality	Large	North Holland
Participant 12	Yes	Municipality	Large	Overijssel
Participant 13	Yes	Waterboard	Multiple municipalities	-

3.4. Data Collection & interview guide design

Semi-structured interviews were used to collect data for sub-question 1 and 2. The interview-questions for sub-question 1 focused on the process to identify which decision-making tactics were employed. Next, the interview questions for sub-question 2 focused on the perceptions and context factors that influenced the decision-making process. For these semi-structured interviews an interview guide was designed that was used throughout the interviews. This interview guide is shown in Appendix B in Dutch and English.

Semi-structured interviews were a suitable approach for collecting data, because it is a freer form of interviewing, based on previously designed topics and questions. This approach allowed participants to share information they found relevant, even if it had not been anticipated in the theoretical framework (Bhattacherjee, 2012).

3.5. Data Analysis

Once the interview data was gathered, transcribed and translated, the data was analyzed to derive meaningful insights.

The first analyses have led to the answer to sub-question 1: *How are decisions on climate change adaptation in cities for extreme precipitation events made by decision makers and what is the perfor-*

mance of these processes?. The goal of this sub-question was to identify the decision-making tactics used, based on the framework developed by Nutt (2008). The analysis revealed which tactics decision-makers apply when developing climate change adaptation measures for extreme precipitation events.

The analysis of the interview data began with the development of a predefined set of codes for each process tactic (see Table 3.3), based on the theoretical framework (Figure 4.4). A qualitative coding approach was used to analyze the interview transcripts. The responses of each participant were systematically coded according to the predefined codes, allowing for the identification of specific decision-making tactics that were used during different steps of the process. Individual decision-making processes were discovered, showing which tactics were applied, in which order, by which decision-makers. For each interviewee, these tactics were visually represented in a process map. If a participant mentioned a similar tactic multiple times, it was counted only once to ensure consistency. In other words, coding was done per participant, not per mention. After creating the process maps, patterns were analyzed to determine whether different contextual characteristics, such as municipal size or the initial reason for starting a project, resulted in distinct decision-making processes, this is visible in Appendix D.

Table 3.3: Overview of the decision-making tactics of Nutt (2008)

Code	Description
Nutt_IntGath	
Nutt_IntGath_Needs	Performance driven, calling for better results based on performance measures
Nutt_IntGath_Opp	Stakeholder suggestions, driven for action
Nutt_Direction	
Nutt_Direction_Idea	Reasoning for action, because of benefits implied by idea. Somewhere else it worked, so for us it will work too.
Nutt_Direction_Problem	Defining action based on the analyses of the problem
Nutt_Direction_Objective	Direction based on desired outcomes (hoped for results)
Nutt_Solutions	
Nutt_Solutions_Idea	No search necessary, solution already available
Nutt_Solutions_Benchmark	adopted by someone else
Nutt_Solutions_Solicitation	Ideas found by other external parties (consultants)
Nutt_Solutions_Innovation	Custom-made solution, for the specific context a new solution is defined.
Nutt_Evaluat	
Nutt_Evaluat_Analys	Comparing identified options by data
Nutt_Evaluat_Bargain	Comparing identified options by stakeholder debate / personal views
Nutt_Evaluat_Subject	Comparing identified options by personal experience/ expert experience
Nutt_Evaluate_Judgement	No justification
Nutt_Implemnt	
Nutt_Implemnt_Persuat	Convincing by highlighting the benefits
Nutt_Implemnt_Edict	Decision made by authority
Nutt_Implemnt_Partic	Task force and indicating expected results
Nutt_Implemnt_Interv	Demonstrate performance gaps, built agreement for action

The second analysis has led to the answer of sub-question 2: *What are the different perceptions and context factors that influence the decision-making process of climate change adaptation decisions for adapting to the effects of extreme precipitation events in cities?"*. The goal of this question was to show the influence of contextual factors and perceptions on the decision-making process for climate change adaptation decisions.

The perceptions and contextual factors that influenced the tactics of the decision-making process were assessed in an exploratory way; no predefined codes were used. The methodology for coding was a thematic analysis. A thematic analysis was suitable for identifying and analyzing patterns within qualitative data (Braun & Clarke, 2006). A realistic thematic analysis was used allowing for examining the connections between participants' experiences and their reality. The following steps were used based on Braun and Clarke (2006): First, the transcripts were read carefully to identify meanings and patterns. Second, key features and similarities were identified and recorded as codes. Third, initial codes were grouped into overarching themes. Then, the themes were adjusted to ensure consistency. Fourth, the themes that have been identified were named.

The themes formed the basis for the context maps. These context maps reflect perceptions and contextual causal relationships to the decision-making process. In this context map factors were visualized to illustrate their impact on different process steps. The interview quotes were used to explain choices in the supporting text. The process maps were constructed as follows: the process that was identified in Sub-question 1 was held as a basis. Then the themes that influence the process are visualized and themes that influenced the themes according to the perception of the participants were then also shown. In this way an overview is created of every perceived influence between the themes and on the process. The arrows in the maps are visualizing the influences.

The process maps of every participant are shown in Appendix D. The maps were combined to be able to gain an overview in the results section, this is shown in Figure 5.1. The numbers corresponding the arrows in this Figure represent by how many participants a relation is perceived; this method of evaluation is inspired by Beach and Pedersen (2023).

3.6. Tools

Several digital tools were used throughout the research process to support various tasks. Microsoft Teams was used to record and transcribe interviews. To translate quotes from Dutch to English, Microsoft Copilot was employed, ensuring clarity while maintaining the intended meaning of participants' responses. Visual representations and figures were created using draw.io. Lastly, qualitative data was coded and analyzed using ATLAS.ti, which facilitated qualitative analysis of the collected data.

3.7. Ethical Considerations

Throughout the entire research project, ethical considerations were strictly maintained. To ensure the research complied with ethical standards the following steps were taken. First, a data management plan was created to identify what data was going to be collected and where this data could be stored. The data management plan was discussed with the data manager of Technology, Policy and Management and improved based on the feedback provided. All data was handled according to this plan. Additionally, an informed consent form was created to notify participants on their rights regarding their personal data and collected data. This informed consent form, provided in Appendix C, was provided to the participants before the interview and was signed by them, ensuring they were fully aware of how their data was processed and used. The participants have read the transcripts that were used and agreed on the transcripts before they were used in the research. All output is handled anonymously in the thesis. Finally, all documents were handed in at the Human Research Ethics Committee for revision. The Human Research Ethics Committee approved the data management plan, the application for doing research that involves human subjects, and the informed consent form.

3.8. Validation

To validate the findings, a reflection session was held with five consultants from APPM Management Consultants. During the session, the preliminary results were presented, including process maps and the identified influences and themes. The participants recognized the patterns from their own work with municipalities, confirming that the findings are relevant to real-world practice. However, they noted that subjective tactic was not mentioned in the interview. This contrasted with their practical experience suggests possible response bias. Their feedback added nuance to the analysis and strengthened the interpretation of the data.

4

Theoretical framework design

In this chapter the literature and considerations are discussed to determine the theoretical framework that is going to be used as basis for the data gathering and evaluation process. Sub-question 1 adopts a theory-informed approach, therefore in Paragraph 4.1 an additional literature is conducted to identify different decision-making frameworks. Then in Paragraph 4.2, the framework design is provided for sub-question 1. Finally, in Paragraph 4.3 the complete theoretical framework that is used to answer sub-question 1 and 2 is shown.

4.1. Decision-making frameworks

In the literature different possible decision-making frameworks are proposed to research decision-making processes. The first category of frameworks are discussed in Paragraph 4.1.1, these are dynamic and unpredictable in nature. The next category of frameworks are psychological frameworks, discussed in Paragraph 4.1.2. The final category are linear decision-making frameworks, discussed in Paragraph 4.1.3.

4.1.1. Dynamic frameworks

Dynamic frameworks are described as: *"dynamic and unpredictable nature of policy making that analysts have to deal with"* (Enserink et al., 2022). There are different types of frameworks that try to explain these dynamic processes.

The first dynamic framework is the Multiple Streams Framework developed by Kingdon (1984). This is a policy science approach used to explain how policy change occurs. A conceptual figure of the multiple streams framework is shown in Figure 4.1. The framework proposes that the policy process consists of three relatively independent streams: the problem stream, where issues are recognized as requiring attention; the policy stream, where possible solutions are developed by experts and stakeholders; and the politics stream, which includes political factors such as public opinion, changes in government, and interest group pressure (Enserink et al., 2022). Policy changes happen when these three streams converge during a window of opportunity. An opportunity window occurs when conditions are right for change. MSF is widely used to analyze why certain issues gain political traction and lead to action.

The second dynamic framework is the garbage can model. The garbage can model is an unstructured and chaotic model that tries to describe decision-making (Cohen et al., 1972). A conceptual visualization of this model is provided in Figure 4.2. In the garbage can model different solutions, problems, and decision-makers exist alongside each other. It is not clear who is involved, what solutions there are and what problems there are. But once the opportunity is there, by chance everything comes together and is solved. The result of the decision-making depends on what is in the garbage can and the timing (Enserink et al., 2022), the results are based on coincidence and cannot be predicted.

The third dynamic framework is the Rounds model. Like the multiple streams framework and the garbage can model, in the Rounds model, decision-making takes place in rounds and arenas (Enserink et al., 2022; Teisman, 2000). A conceptual visualization is represented in Figure 4.3. Activities

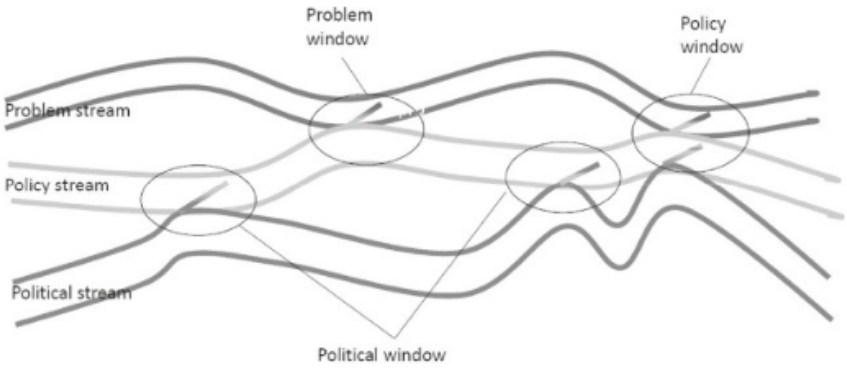

Figure 4.1: Visualization of Multiple streams framework (Enserink et al., 2022)

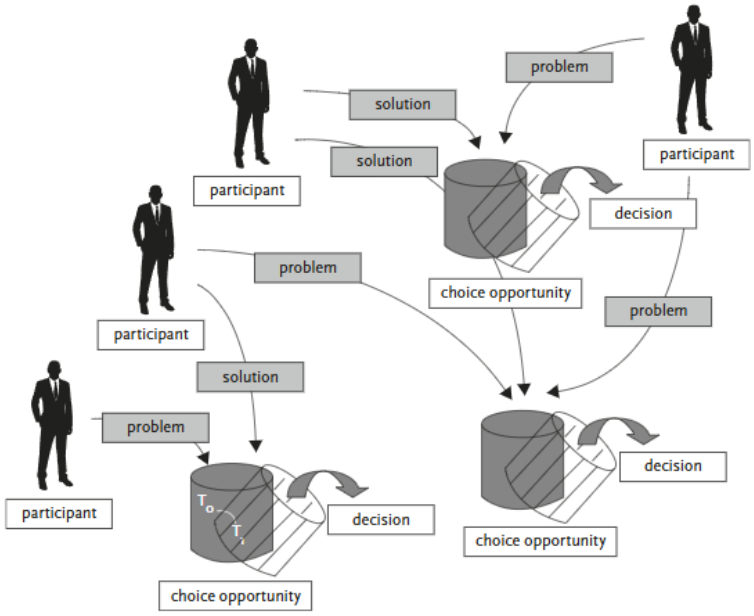

Figure 4.2: Visualization of garbage can model (Enserink et al., 2022)

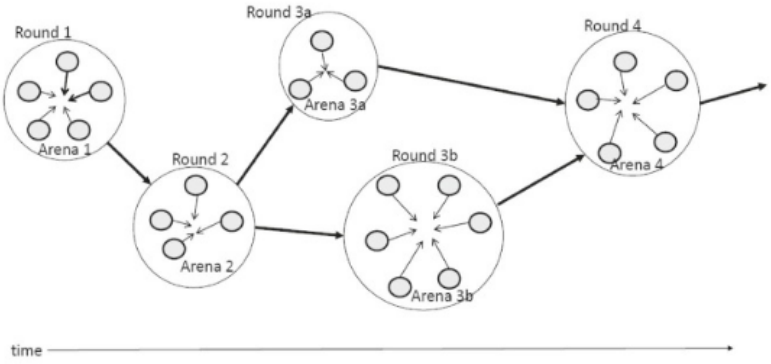

Figure 4.3: Visualization of Rounds model (Enserink et al., 2022)

in these arenas vary a lot: they could be focused on exploring problems, designing solutions, or a combination. These arenas and rounds can exist at the same time and participants can be involved in multiple rounds.

4.1.2. Psychological frameworks

Psychological decision-making frameworks help explain how individuals assess choices, weigh risks, and make judgments based on cognitive, emotional, and social factors. Different psychological decision-making frameworks, each explaining a different view of psychological decision-making.

The first psychological framework is the dual process theory, also known as System 1 and System 2 thinking (Orlove et al., 2020). System 1 refers to fast, intuitive, and automatic decisions, while System 2 involves slower, deliberate, and rational thinking. As discussed in Chapter 2, climate change adaptation decisions for the public sector are expected to rely more on System 2 thinking, due to the high costs and long-term of the measures (Siders & Pierce, 2021). However, in practice, fully relying on System 2 is difficult, because the problems are unstructured. Therefore, decision-makers may fall back on system 1 (intuition), or a combination of system 1 and system 2 (heuristics). This creates challenges: heuristics leave it unclear which factors are being considered or ignored, and intuitive decisions are hard to evaluate when the effects become clear in the future (Siders & Pierce, 2021).

A second psychological framework relevant to this research is bounded rationality (Simon, 1955). This concept suggests that individuals are not capable of evaluating all possible options due to limitations in information, time, and cognitive capacity. Rather than aiming for the optimal choice, people usually seek a choice that is good enough. Climate change adaptation decisions are often complex, due to an overwhelming number of options or the perception that climate impacts are distant. Bounded rationality explains that when the process feels too complex, postponing or avoiding action can become the most psychologically comfortable choice.

A third psychological theory is the prospect theory (Kahneman & Tversky, 1979). The prospect theory explains that people value loss more than profit. Possibly, this framework can explain the behavior of risk in climate change adaptation. This is also discussed Chapter 2: When people experience climate change impacts, they are more willing to implement measures (Amundsen et al., 2010; Arnbjerg-Nielsen et al., 2015; Madsen et al., 2019). Even the perception of high risk, leads to more adaptation measures that are implemented (Dilling et al., 2017; Lindell & Perry, 2011; Wolf et al., 2021).

4.1.3. Linear models

The next category of models are linear models designed for analyzing individual-level decisions. In linear models single-step process frameworks are developed. E. F. Harrison (1996), Keeney (2004), Lang et al. (1978), Lunenburg (2010), and Nutt (2008) all identified step-by-step decision-making process frameworks, which emphasize the rational stages that decision-makers follow. The steps they have identified are shown in Table 4.1. All are based on 'a reason for action', 'structuring the problem',

'searching for alternatives', 'evaluating the alternatives', 'implementing the alternatives' and 'evaluating the performance' or a different name for the same steps (Scholten & Oomens, 2024).

Table 4.1: Decision-Making process steps frameworks of E. F. Harrison (1996), Keeney (2004), Lang et al. (1978), Lunenburg (2010), and Nutt (2008)

Nutt (2008)	**E. F. Harrison (1996)**	**Keeney (2004)**	**Lang et al. (1978)**	**Lunenburg (2010)**
Intelligence gathering	Setting objectives	Structuring & Defining objectives	Actual problem (Gap)	Identifying the problem
Directions from	Searching for alternatives	Specifying attributes for measurement	Problem identification activities	Generating alternatives
Solutions found by	Comparing & evaluating alternatives	Quantifying trade-offs & preferences	Problem perceptions	Evaluating alternatives
Evaluation	The act of choice	Generating & evaluating alternatives	Motivation to solve problem	Choosing an alternative
Implementation	Implementing decisions	Implementing decisions	Ability to solve problem	Implementing the decision
-	Follow-up & control	Monitoring	Ability to implement a solution	Evaluating the decision

4.2. Theoretical Framework design for sub-question 1

Dependent on the research goal, a decision-making framework can be chosen (Nutt, 2011). Each decision-making framework reinforces their own assumptions; When decision-making is viewed as a linear process, it is interpreted as such. However, when the political or opportunity perspective is emphasized, the decision-making process is instead interpreted through the lens of political or opportunity aspects (M. Harrison & Phillips, 1991; Nutt, 2011).

This research focuses on how individual municipal decision-makers make choices. For this purpose, it is more appropriate to view decision-making as a sequential and rational process. Models such as the 'rounds model,' the 'garbage can model,' and the 'multiple streams framework' (Cohen et al., 1972; Kingdon, 1984; Teisman, 2000) have not been adopted here. These approaches focus on macro-level environments, where decisions emerge through unstructured processes and chance rather than deliberate planning.

Although psychological factors have been widely discussed in the climate change adaptation literature (Amundsen et al., 2010; Arnbjerg-Nielsen et al., 2015; Bellmann et al., 2025; Dilling et al., 2017; Lindell & Perry, 2011; Madsen et al., 2019; Siders & Pierce, 2021; Wolf et al., 2021), this study does not adopt a psychological framework. Instead, the focus lies on a step-by-step decision-making framework. This approach allows for a more structured understanding of how individuals make climate change adaptation decisions over time, without requiring in-depth psychological analysis. As individual-level decision-making remains relatively underexplored in this context, a step-by-step framework can provide practical insights into adaptation behavior (Siders & Pierce, 2021).

Since E. F. Harrison (1996), Keeney (2004), Lang et al. (1978), Lunenburg (2010), and Nutt (2008) all identify similar steps, this confirms the validity of these phases in decision-making. A key advantage of Nutt (2008)'s framework, compared to the others, is its focus on the different tactics decision-makers use within each phase. This makes the Nutt (2008) framework a strong choice for evaluating the decision-making process, as the tactics offer a structured and practical foundation for analysis. However, a limitation of Nutt (2008)'s model, is that it does not explicitly include a step for evaluating decisions. Although monitoring and evaluation are essential components of adaptive management (Moser & Ekstrom, 2010), assessing the outcomes of climate adaptation is particularly challenging, since the effectiveness of such measures often only becomes apparent in the future (Siders & Pierce,

2021). Therefore, the absence of this step in the Nutt (2008) framework is acceptable for this study, as it focuses on decision-making processes rather than long-term outcomes.

Because Nutt (2008) links concrete tactics to each step in the process, his framework will guide the structure of this research. Table 4.2 outlines the steps, tactics within each step, descriptions and the effectiveness. The Nutt (2008) framework was originally created for company decisions, but is expected to be equally relevant for governmental and public decision-making. This expectation is based on the framework's evaluation criteria, adoption, value, and efficiency, which are applicable to both corporate and governmental decisions. Additionally, Bassone-Quashie (2021) applied the Nutt (2008) framework to assess governmental and municipal decisions for sewer systems. Furthermore Nutt (2005) used the framework to compare decision-making in the public and private sectors, confirming the applicability to governmental contexts.

Table 4.2: Tactical options for process steps (Nutt, 2008)

Tactic	Description	Example	Performance
		Intelligence Gathering	
Needs	Identifying needs based on performance data, observations, or trends.	Experience with extreme rainfall leads to nuisance in an area. The municipality realizes that they need to do something on Climate change adaptation	More successful
Opportunities	Action driven, suggestions by stakeholders	An NGO or expert group proposes to implement climate change adaptation decisions	Less successful
		Directions from	
Ideas	Reason for acting from benefits implied by idea	Standard in every project a municipality decides to design the sewing system in a standard climate adaptive way	Less successful
Problems	Defining actions based on problem analysis.	The municipality analyzes flood-prone areas and determines which locations should be prioritized.	Less successful
Objectives	Setting direction based on desired outcomes.	The municipality sets a goal to retain 50 mm of water in a certain area	More successful
		Solutions Found By	
Ideas	No search, solution available	The municipality chooses a standard solution, such as raising dikes, without extensive research.	Less successful
Benchmarking	Adopting best practices from others	Climate adaptation solutions that have been successfully implemented in other cities are chosen	More successful
Solicitation	Requesting solutions from external consultants.	Consulting firms and research institutions are consulted to provide proposals.	More successful

Tactic	Description	Example	Performance
Innovation	Designing a custom solution.	The municipality considers innovative solutions that are specifically tailored to the specific situation	More successful
		Evaluation	
Analysis	Comparing options using performance data, records, and reports.	Cost-benefit analyses and climate models are used to predict the effectiveness of different measures.	More successful
Bargaining	Stakeholders debate and rank different options.	Politicians, stakeholders, and citizens discuss options and attempt to reach a broadly supported decision.	More successful
Subjective	Decision based on expert opinion or personal experience	Experienced water managers and policymakers provide input based on their previous projects.	Less successful
Judgement	No justification for decision offered.	A decision is made without extensive analysis or justification.	Less successful
		Implementation	
Persuasion	Convincing stakeholders by highlighting benefits.	Emphasizing the benefits of the chosen approach to convince residents, businesses, and civil servants.	Less successful
Edict	Directly enforcing a decision through authority.	Implementing measures through political decisions	Less successful
Participation	Delegating a team to implement the decision	Residents, departments and businesses are actively involved in the implementation.	More successful
Intervention	Demonstrating performance gaps to build consensus for action.	Pilot projects demonstrate the effectiveness of measures, increasing public support.	More successful

The overview of the theoretical framework used for sub-question 1 is shown in Figure 4.4. The gray box represents the entire decision-making process. The green boxes that are connected represent the process steps and the boxes connected to these steps indicate the tactical options. Each tactical option is color-coded according to the corresponding project step. To answer sub-question 1, for each process step, one tactical option is identified, which is a tactic that is used by the decision maker.

4.3. Complete overview theoretical framework

Figure 4.5 presents a complete overview of the research framework, combining the structures used to answer sub-questions 1 and 2. The framework represents the Nutt (2008) framework phases, the choices of tactic that can be made within the Nutt (2008) framework, and the context factors and perceptions that influence the complete process and every decision-making phase.

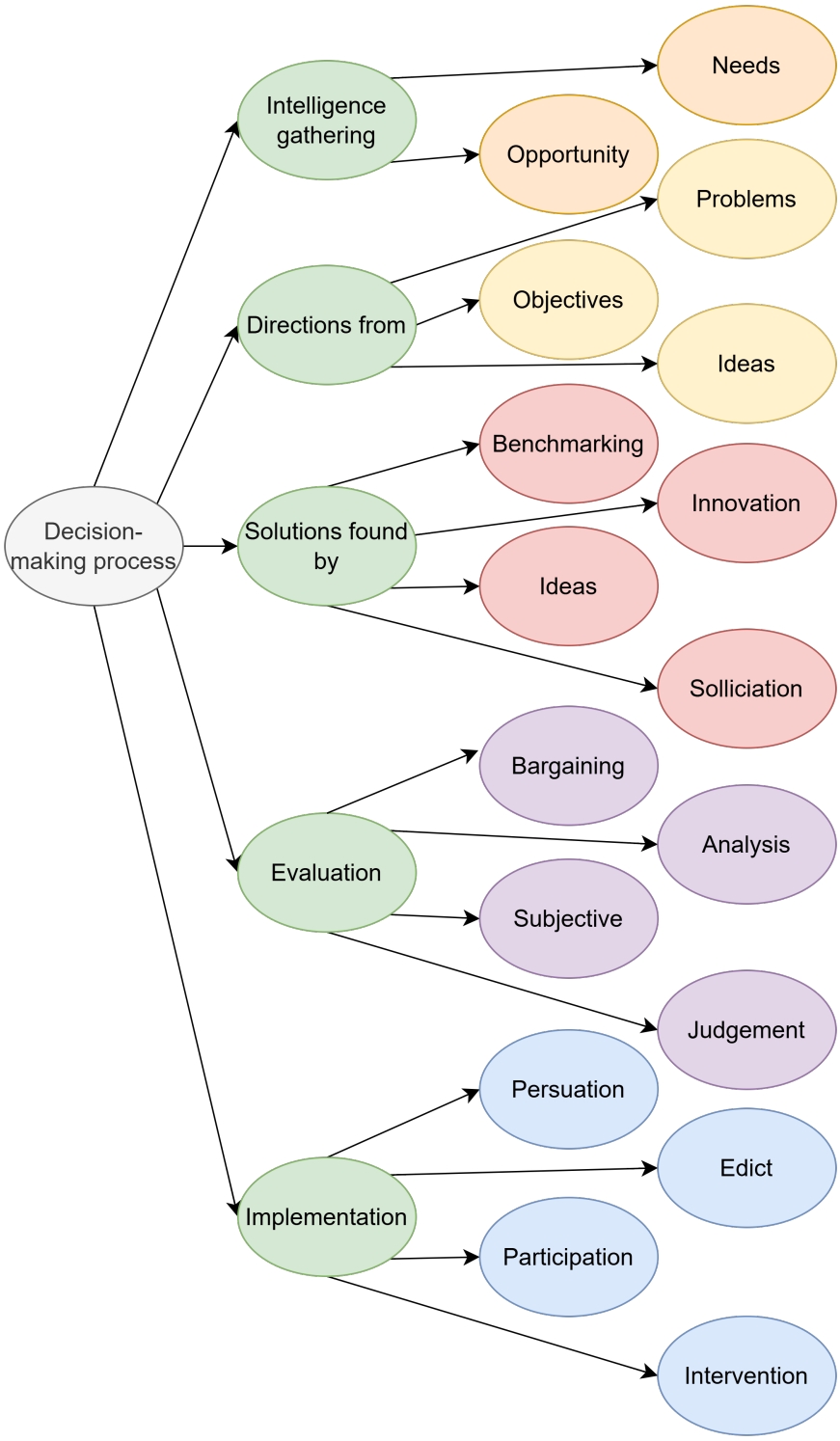

Figure 4.4: Theoretical framework sub-question 1

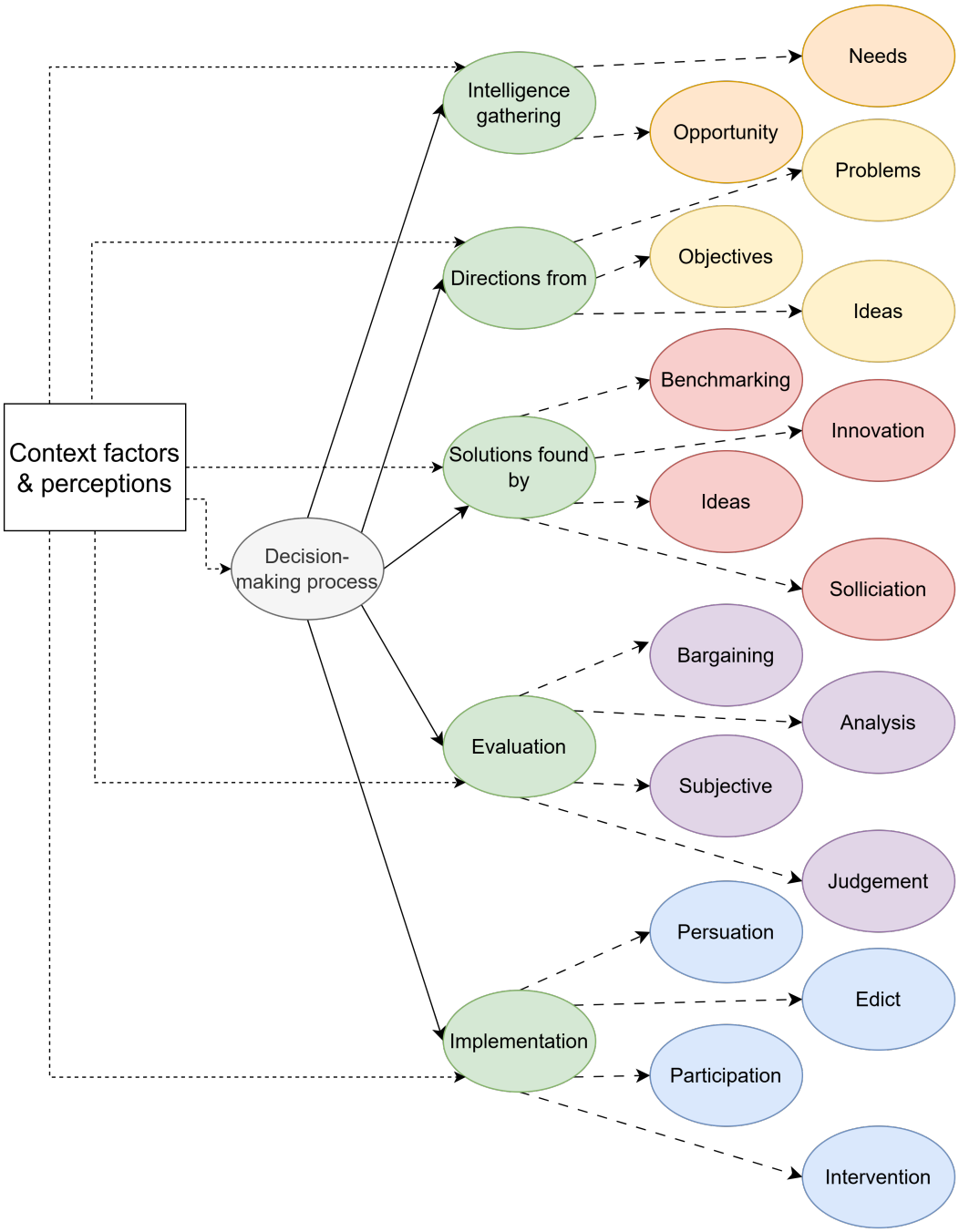

Figure 4.5: Theoretical framework used to answer the main question, combining sub-question 1 and 2. The dotted line shows how context factors and perceptions influence different parts of the decision-making process. The dashed line indicates the various tactics used within each phase. The solid line represents the main phases of the process.

5

Results

The results of the analysis are provided in this chapter. In Paragraph 5.1, the decision-making process, perceptions and context are discussed. Then, in Paragraph 5.2 the general influences on the process are discussed.

5.1. Results decision making process, perceptions and context

This section explains the process tactics that were identified based on the Nutt (2008) framework process and the insights that can be derived from the context factors that are perceived to influence the process tactics. Appendix E provides an overview of the tactics that were used in the decision-making processes of each participant. An overview of the process tactics used, with example quotes are provided in Table 5.1. Figure 5.1 reflects an aggregated combination of the process maps of each interview, details can be found in Appendix D.

Table 5.1: Overview of Mentioned Codes in Nutt Framework

Nutt Process Tactic	**Mentioned (N = 13)**	**Example Quote**
Intelligence Gathering		
Opportunity	11	*"Area development often provides an opportunity to do something with climate adaptation."*(P1)
Needs	7	*"From the municipality, it indeed received that priority because the nuisance in this whole area was so severe."* (P1)
Directions From		
Objective	11	*"The task is quite concrete: how many cubic meters of water and where, also with heat.*" (P6)
Idea	1	*"Then it gets interesting, because enthusiasm arises. Some people and I can say I'm one of them, try to build a solid case for why this adds value to the city."* (P2A)
Problem	6	*"So we first look at: what's the problem? We model scenarios like: what happens if we do nothing?"*(P9)
Solutions Found By		
Solicitation	5	*"So we hired an agency to calculate and research that."* (P6)

Continued on next page

Table 5.1, continued from previous page

Nutt Process Tactic	Mentioned (N = 13)	Example Quote
Idea	5	*"Technically, we try not to implement too many different systems in public space. We design with maintenance in mind, so we have design guidelines. That way, we avoid creating a patchwork of systems that each require separate maintenance."* (P5)
Innovation	5	*"We believe it should be possible to build a park at X using techniques from greenhouse horticulture, where they collect and purify water and store it 20 meters underground*." (P2A).
Benchmark	4	*"It's quite difficult to find a proven good technique, but we do look at neighboring municipalities for what they apply."* (P6)
Evaluation		
Bargain	6	*Regarding ambition levels, that's one of the trickiest parts. Each discipline brings in their wishes: trees, parking, district heating, storm-water drainage, etc. It all goes into the project, but during the design phases, you realize it doesn't all fit."* (P5)
Judgment	1	*Without deep investigations, we didn't really check whether this or that was truly necessary."* (P2A)
Analysis	8	*I just want to be able to prove that your measures make sense. So that's not even innovative, just show that you do it."* (P11)
Subjective	0	-
Implementation		
Intervention	1	*Also because there were already tasks in the public space. But I think you can say the reports we received led us to approve the works."* (P7)
Edict	4	*"Based on the participation process and its outcome, the council said: fine, go ahead with that creek."* (P12)
Persuasion	4	*It comes down to seeing a project positively to make a decision. If your attitude is negative, you won't reach one. Regardless of the alderman's political color, you need to make it work."* (P4)
Participation	3	*There's a whole process before it's approved. It goes to the core team, and after that through the municipal departments: maintenance, finance, etc. Once all approve, then it's finalized."* (P9)

5.1.1. Phase: Intelligence gathering

The first phase identified in the framework by Nutt (2008) is the "Intelligence Gathering" phase. This phase focuses on finding a reason to initiate a project. Within this phase, two main tactics are distinguished: "Opportunity" and "Need."

The "Opportunity" tactic refers to acting when external stakeholders or contextual factors create a window of opportunity. As shown in Table 5.1, the "Opportunity" tactic was mentioned in most of the cases (by 11 of the 13 participants). As can be seen in Table 5.2 the most frequent type of "Opportunity" mentioned is the stress test obliged by the DPRA. In the Netherlands, as described in Chapter 2.1, the DPRA requires every municipality to carry out stress tests. These stress tests are typically the starting point for climate adaptation efforts in municipalities. The purpose of the stress tests is to identify vulnerable areas. For one municipality, the DPRA stress test was the sole reason the project began, although no measures have been implemented here. As explained: *"So how do you become climate-adaptive by 2040? Well, we started with stress tests. These revealed that several neighborhoods are highly vulnerable and do not meet standards. Some neighborhoods perform reasonably well. We focused mainly*

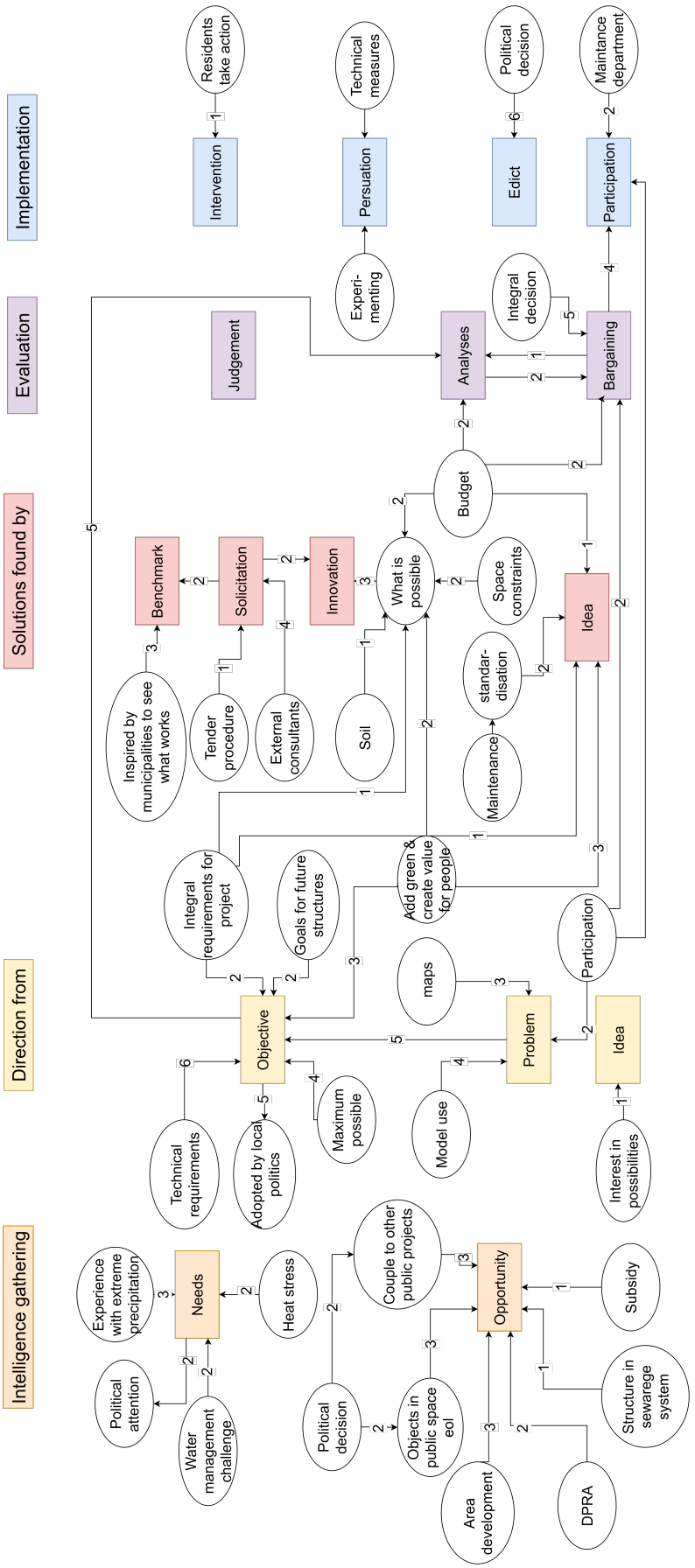

Figure 5.1: Nutt process tactics influences perceived in the interviews. Every arrow represents a perceived relationship, the number corresponding to the arrow shows how often this relationship was perceived

on heavy rainfall and heat, those two themes and zoomed in further on them." P6. After completing the stress test, municipalities often wait for other opportunities to proceed further. Another frequently mentioned opportunity is area development, cited three times (see Table 5.2 and Figure 5.1, column "Intelligence Gathering"). In these cases, climate adaptation measures are integrated into the project from the outset. Area development provides flexibility in terms of design and available space, allowing for highly adaptive plans. One participant noted: *"Area development often provides an opportunity to address climate adaptation."* P1. Another "Opportunity" is project coupling. This means connecting climate adaptation measures to ongoing projects in other municipal departments. Because adaptation can be expensive, coupling efforts to existing projects helps justify and fund them. An example quote of project coupling is: *"I think we mainly try to see if we can ride along with each other and combine efforts." P3*. This coupling approach often increases the available budget, as expressed in another interview: *"Our strategy is now to resolve these bottlenecks as much as possible by linking them to planned works. We are fully committed to making use of coupling opportunities."* P7. The third type of "Opportunity" is the replacement of end-of-life (eol) infrastructure. This means that sewage systems or other objects in public space need to be replaced. Explained by: *"When there are sewer works, we indeed try to combine tasks and align efforts."* P3. The final reason for an "Opportunity" is future proofing infrastructure, such as redesigning sewerage systems with future climate scenarios and sewing design structures in mind. Explained by: *"And when it comes to making a few interventions in public space… we first need to secure the main structures."*

Table 5.2: Overview of codes and frequencies tactic "Opportunity"

Code	Number of times cited (N=10)
Area redevelopment	3
Project coupling	3
EOL	3
Future proving & structuring infrastructure	1
Subsidy	1
Political decision	5
Stresstests from DPRA	Obligation so all municipalities did this

The second tactic in the "Intelligence gathering" phase was the "Needs" tactic. This tactic is defined by Nutt (2008) as: "*calling for better results based on performance measures."* As can be seen in Table 5.1, the "Needs" tactic was mentioned 7 times in 13 interviews. There are several factors that are equally perceived to influence the "Needs" tactic, these are shown in Table 5.3 and Figure 5.1, column "Intelligence gathering". The first factor that has led to a "Need" is an experience with an extreme precipitation event and the impact of it: *"It's been two years now, but back then an extreme rainstorm hit that area. A storm that normally only occurs once every thousand years. But it happened to fall right there. All the parquet floors in the neighborhood started to float. There was 20 cm of water on the streets, or even more in some places. That really became the catalyst for us to seriously start addressing water nuisance and climate adaptation in the municipality." P10*. Another reason why the "Needs" tactic was identified in the interviews was that there was a poor condition of the public spaces. As mentioned by: *"From the municipality's side, it received priority because the nuisance in the area was so significant." P1.* and similar by: "*We saw that the area was very paved, and that several public space objects were really due for replacement. The pavement quality was poor, and the growing conditions for the trees were very limited." P7.* A third reason was that water management challenges occurred in an area. Supported by "*So it's currently a very urban, paved area, with a lot of water nuisance, actually. The whole neighborhood suffers from it. X is, of course, very low-lying, and what we also see is that there's hardly any space for the water to go, not even to infiltrate into the ground. That's why there's so much flooding."* P1. The final contextual factor that led to "Needs" was heat stress, explained by: *We just want more shade there, because it's an incredibly hot street. It's at least four or five stories high, and there's nothing but asphalt or concrete, maybe a few small trees.* P4.

In 5 out of 7 cases where a "Needs" tactic was mentioned, also an "Opportunity" tactic was adopted. In these situations, the local government was waiting for an opportunity to implement climate change adaptation, but then experiences a heavy rainfall event; this often serves as a catalyst for implementing

Table 5.3: Overview of codes and frequencies tactic ”Needs”

Code	Number of times cited (N=7)
Experience with rainfall	3
Water management challenge	2
Heat stress	2
Political attention	2

measures. This was also the case in: *”On that evening itself, we told residents: yes, we knew it’s coming, but at that time there was still no moment planned for redesigning the public space. So, it just wasn’t on the agenda yet.” P10.* Often, the municipalities started with an ”Opportunity” tactic, because the municipalities were forced to perform stress tests based on the Delta program. Then they had identified the vulnerable and risk areas, but there was no need yet to start implementing the climate change adaptation measures. In these cases, the ”Needs” tactic followed experience with an extreme weather event and the resulting nuisance. Suddenly, political attention was high and political pressure allowed implementation action

The decision on when projects can start depends on local politics, for the ”Needs” and ”Opportunity” tactics. For example, some interviewees noted that political decisions determine whether the ”Opportunity” of eol replacement or project coupling alone justifies climate change adaptation. The reason why this is justified is that if the climate change adaptation measures are implemented without coupling it to other projects, this is seen as capital destruction. As explained by: *”I mean, you’re not going to dig up a sewer and replace it with a larger pipe if it hasn’t reached the end of its lifespan yet, that would be a waste of capital.”* P3. When a ”Needs” tactic is identified, this often leads to political attention to the issue, which creates urgency and can lead to increased action to reduce the nuisance, by implementing climate change adaptation measures. This was mentioned in the interviews by: *”This created a strong sense of urgency to take immediate action, as political attention was high and residents were aware of the consequences of water-related issues.” P10.*

5.1.2. Phase: Directions From Phase

The next phase identified by Nutt (2008) is the ”Directions From” phase. This phase determines the source from where solutions to the identified problems will originate. As shown in Table 5.1, three tactics are defined in this phase: ”Idea”, ”Problem”, and ”Objectives”. ”Objectives” were mentioned the most frequently (11 out of 13 times), the ”Idea” tactic was mentioned only once and the ”Problem” tactic was always mentioned in combination with ”Objectives”.

The ”Idea” tactic is based on enthusiasm for the idea itself and the potential benefits it might bring, rather than on a solid analytical foundation. This approach was only found in P2A (1 out of 13 interviews), where a highly innovative project was described. The aim was to test whether the innovative concept would work, with little prior research conducted on its actual effectiveness, this is seen in Figure 5.1, column ”Directions From”. *”That’s when it gets interesting, because enthusiasm emerges. Several people, including myself, then try to create a compelling and coherent story. Why is this valuable for the city?” P2A.* This ”Idea” was implemented without extensive preliminary goals or problem evaluation.

The ”Objectives” tactic means that goals are defined in the ”Directions From” phase, guiding what is to be achieved. The ”Objective” tactic was identified in 11 out of 13 municipalities. Interestingly, ”Objectives” vary in their level of specificity and ambition. The different types of ”Objectives” that are mentioned during the interviews are discussed; an overview is provided in Table 5.4 and Figure 5.1 column ”Directions From”. The first type of ”Objective” was that technical requirements were specified; this ”Objective” was mentioned most often (6 out of 11 times). In these cases, the goals are based on specific, quantifiable targets. Examples are the amount of water storage or houses that should be close to a cool place. For example: *”In most of X, the standard is to retain 70 mm of water. But in this specific part of X, we say: no, we need to retain 80 mm without causing any damage.”* P9. The second type of ”Objectives” was described more broadly: achieving “as much as possible” within the existing constraints. This non-quantified target was intended to maximize climate adaptation efforts wherever feasible. As mentioned by: *”But we did look at what was maximally achievable. So, we aimed to do as*

much as possible, with the basic principle being an improvement over the current situation." P7. In this case there are no quantitative goals as, they *"didn't make the goals very measurable. For example, we didn't specify how much shade or how many cubic meters of water storage." P7*. The third type of "Objectives" focused on improving spatial quality, such as creating a more pleasant living environment or adding green space. This was mentioned in 3 interviews, an example is *"That prompted us to approach it as a project, in which we're now focusing on greening, creating more space for water retention and social interaction and consequently, slightly less space for cars."* P7. The fourth type of "Objective" defines goals based on the desired future structures of the sewing system. An example of this is: *"Well, you know, the challenging part [...] is that you're working on a city over a span of 20 years, where different plots are being developed at different times, and by the end of it, everything needs to come together as a consistent whole. That applies to urban planning, mobility, but also to water management, right? Everything must connect."* P5. The final type of "Objective" was that climate adaptation goals were incorporated into the integral project requirements, alongside goals from other municipal domains, such as mobility or energy. An example is: *"That's where integrated programming takes place. [...] In that, you find the task, requirements, and ambitions for the project: climate adaptation, greening, heat stress, all included."* P3.

When the "Objectives" were set, they were also adopted by local politics. In this way the objectives were no longer optional but gained an obligatory sense to keep them. An example quote is: *"What we then say is: "Let's also establish that in the executive board, not the municipal council, but the board of mayor and aldermen. We find that important, because it means the board formally agrees with what we want to do."* P6. A difficulty with the "Objectives" is that often the goals are impossible to reach. This is mentioned by: "*For many, or at least some of the indicators, it's actually quite logical what measure you should take. For example, if one of the indicators we're looking at is: "How many trees can a resident see from their home?" well, if that's too low, then the solution is to plant more trees in the street. But whether that's feasible, both in terms of budget and available space, that's of course not captured in the analysis itself." P8*.

Table 5.4: Overview of codes and frequencies tactic "Objective"

Code	Number of times cited (N=11)
Technical/ specific requirements	6
General goals	4
Spatial quality	3
Future system integration	2
Integral project requirements	2

In the "Problem" tactic, action follows from a careful analysis of the problem. Municipalities conduct additional research to understand the challenges in a particular neighborhood. The tactic "Problem" was mentioned in 6 out of 13 interviews, as is shown in Table 5.1. An overview of the influences of factors on the "Problem" tactic is provided in Table 5.5 and Figure 5.1, column "Directions from". The first way for analyzing the "Problem" was using maps. To do so, participants defined the current performance for every street in a map, for example by using labels A through E or score 1 through 5 or high, medium, low risks for every street and neighborhood in the municipality. In the case of the Labels, they indicate the current state of climate adaptation performance and what is required to reach a "B label," which stands for climate adaptiveness. Based on their current performance and the goals as described by the B label, specific goals are set. *"We basically did a kind of stress test 2.0. We used existing datasets to assess where the biggest challenges still lie, where the most needs are, and where things are already going well across various themes."* Further elaborating: *" 'A' means you're doing even better than required. Labels B through E indicate progressively worse performance. We define label B based on what research suggests, but also using national guidelines and sometimes our own local policies. Especially around water, you'll find a lot already embedded in sewer policies. So, we extract some of that from there." P8*. But with these methods, some other problems arise. The analysis shows that now the goals are clear, but reaching Label B is impossible because of limited space or limited budget. Another way to define the "Problem" tactic was by technical modeling to understand the problem in depth, such as simulating water flows or stress tests. *"This is how we do it now: we*

are building a Digital Twin environment. In it, we recreate our neighborhood or in this case, it has already been recreated." P11 and what they do then is: "*We incorporate the labeling standards into it. So, we can say: label B is the standard, and this is what it means. Then you run a simulation of the neighborhood in the Digital Twin with a specific rainstorm, or a certain sun position, or other extreme weather conditions. And then you can see: how do you perform under those circumstances?" P9*." Finally, some participants visited the locations where the project would take place to analyze the "Problem". They spoke with local residents and checked whether they recognized the outcomes stress tests that had been carried out and whether they were familiar with the identified issues.

Notably, in every interview where the "Problem" tactic appeared, the "Objective" tactic was also mentioned. Models are used to analyze the situation ("Problem"), and the outcomes of that analysis are translated into concrete goals ("Objectives"). An example is: *"That means we define a water challenge. For example, imagine a neighborhood hit by a heavy downpour. Using a model, we looked at what happens, where the water flows, where things go wrong, which houses flood, and which streets and roads become impassable. From that, we determined the water challenge in cubic meters, the volume of excess water that causes nuisance and needs to be removed. That's essentially our starting point." P6*.

Table 5.5: Overview of codes and frequencies tactic "Problem"

Code	Number of times cited (N=6)
Maps	3
Model use	4
Participation	2

5.1.3. Phase: Solutions found by

The next phase in the Nutt (2008) framework is "Solutions found by", which refers to the way municipalities identify measures. 2 out of 13 interviews did not pass the "Solutions found by" phase, no projects were yet implemented. The tactics that could be identified in the "Solutions found by" phase are "Idea", "Benchmark", "Innovation" and "Solicitation" and all mentioned equally in the interviews, as is shown in Table 5.1.

The "Innovation" tactic involves applying a new solution for every situation. This could be new, untested solutions out of interest or ambition. The "Innovation" tactic is mentioned 5 out of 11 times during the interviews. An overview of the factors that influence "Innovation" is provided in Table 5.7 and 5.1 column "Solutions found by". "Innovation" is typically identified when there is curiosity to test a new approach and when there is budget available for experimentation. For example: *"We believe it should be possible to build a park at X using techniques from greenhouse horticulture, where they collect and purify water and store it 20 meters underground." P2A.* Or when the standards are set very high for climate change adaptation: *"This is a project where we really pushed the envelope on climate adaptation. There's a rooftop landscape you'll see later, and stairs leading up to it. This roof has multiple front doors opening onto it. It's super climate-adaptive. We've got systems that capture water on the highest rooftops and allow it to infiltrate gradually before being discharged. It's a really cool project." P1.* The challenge is that innovative solutions are untested and carry more risk, as noted by: *"So, a lot of innovative techniques [...] are still very maintenance-sensitive or don't work well with high groundwater tables. But all of that is still developing. So, sometimes we deliberately keep options open and say: when it's time to replace the sewers, we'll look closely at what's possible at that moment. Then we'll investigate which measures really make sense." P6*. They wait as long as possible to decide which measures they want to go implement in a neighborhood: *"The tricky part is that technology keeps evolving. There's such a range of possible solutions now and our maintenance teams often have strong opinions, whether positive or negative. They'll say, 'It has to be maintainable and affordable.'" P4*. Other factors that lead to "Innovation" are that the municipality is exploring what is possible within the constraints of a specific area. This approach was mentioned in 3 interviews. Examples of constraints are first budget limitations, an example is "*If there's no funding, those ambitions often aren't included, or are only included in a watered-down form, but the project still goes ahead." P3*. The second constraint was space *"Because it's such a complex project right in the middle of the city, you had to be innovative. You*

couldn't just say, 'Let's do it the usual way.' So, complexity demands innovation. Scarcity also demands innovation, because there simply wasn't much space. And those are the kinds of places where more really happens." P1. The third constraint was soil conditions, *"Then it's a matter of looking: where are we located? Are you on top of the push moraine, where the groundwater level is 60 meters deeper? Or are you more toward the old polder grounds? And what if there's a four-story building, how does that affect the water level at that moment? Those are completely different types of measures. We have very diverse neighborhoods in that regard." P4*. And finally, the integration of project requirements from various departments determines the "innovation": *"And eventually it is a puzzle in a very integral plan." P13*.

The "Benchmark" tactic refers to municipalities looking at what others have done, using those examples as inspiration for their own decisions. This approach was mentioned in 4 of 11 interviews and the influences are shown in Figure 5.1, column "Solutions found by". As explained, the tactic "Innovation" had as a challenge that the effectiveness and maintenance of the solutions were often not yet clear. "Benchmark" is mentioned as a solution for these problems with "Innovation", this was mentioned by: *"It's quite difficult to find a proven technique, but we look a lot at what neighboring municipalities are doing and what they're implementing."* P6. By learning from others, municipalities aim to reduce uncertainty and increase the likelihood of implementing robust and effective measures. Participants described how visiting other cities helped them explore new solutions and better understand what works in practice. As one respondent explained: *"This has been implemented throughout the Netherlands, X, X, and X, they have quite a lot of these kinds of facilities in place. So, we also visited a few of the smaller municipalities in X."* P9. Another interviewee shared a similar experience: *"They've created shell-based water storage along the road, which is quite interesting, we went there to take a look ourselves. There were lessons learned: some things went well, others not so well, but they have taken concrete measures."* P6.

The "Idea" tactic of the "Solutions found by" phase is mentioned 5 out of 11 times in the interviews; an overview of the factors that influence the "Idea" tactic is provided in Table 5.6 and 5.1 column "Solutions found by". In the "Idea" tactic, the solutions are based on standardization. This means that no in-depth research into the most effective measures is conducted. For instance: *"And what we normally do is design sewers based on a standard design storm. These are, well, about ten storms that are listed in the RIONED catalog. And I think in the past we used to design the sewer for storm 8, and now we try to do that for storm 9, so that a bit more water can go through the sewer. And what we normally do is disconnect, so we direct the rainwater to surface water. And not through the sewer pipe to the water treatment plant." P3.* Standardization in the "Idea" tactic, ensures that maintenance departments can apply consistent approaches across different locations. This was mentioned as: *"Technically, we try not to implement too many different systems in public space, because you want to design with maintenance in mind right from the start. So, we have design handbooks for that, to make sure you don't end up with a patchwork of systems that all require different types of maintenance." P5.* In some cases, "Idea" stems from earlier decisions regarding budget or way of working.

Table 5.6: Overview of codes and frequencies tactic "Idea"

Code	Number of times cited (N=5)
Maintenance	2
Add green	3
Budget	1

Create added value for residents by introducing green spaces, could stem from either an "Idea" or an "Innovation" tactic. "Innovation" to add value was mentioned in two interviews. *So instead, if you say: let's look at how we can make this area a pleasant and livable space, a place where you'd want to spend time, then you get somewhere. I once said: if I want to green a little square somewhere in X, and the residents want a barbecue area, then sure, they'll get a barbecue area. We create a nice dip in the greenery, and when it rains heavily, that dip fills with water. But you're not barbecuing then anyway. So, they get a beautiful square they can use as they wish, and when I return to the office, I call it climate adaptive."* This helps to create public support, and decision-makers can often use tactics to improve the living environment, to implement less popular measures. When they have not researched anything

specifically and just want to add more green to an area, it is considered an ”Idea”.

Table 5.7: Overview of codes and frequencies tactic ”Innovation”

Code	Number of times cited (N=5)
See what is possible?	3
Soil	1
Add green & create value for people	2
Space contraints	2
Budget	2

In the ”Solicitation” tactic, external consultants are hired to recommend the best solutions. This often happens via tenders or consultancy contracts. The ”Solicitation” tactic is mentioned 5 out of 11 times in the interviews. The perceived influences are shown in Table 5.8 and Figure 5.1 column ”Solutions found by”. ”Solicitation” always overlaps with either the ”Innovation” (2x) or ”Benchmark” (2x) tactic. ”Solicitation” precedes ”Innovation” when external firms bring in new techniques or experimental ideas. This is mentioned when: *”It’s a civil engineering firm, X, so they already had a lot of measures ready to go. I’ve also visited the Green Village in Delft several times to see what innovative solutions are available that we might apply in X. I passed that information on to X [engineering firm]” P10.* ”Solicitation” precedes ”Benchmark” if the engineering firm knows what is happening in other municipalities and works well there and suggest that for the municipality of the participant.

”Solicitation” could happen via a tender. A tender is a way to adopt very high demands for climate change adaptation in an area development: *”There were multiple bidders, of course, everyone wanted the land. So, the tender had high demands. First, all parties registered, and a pre-selection was made. Eventually, three parties were selected to further develop their plans, resulting in three designs, one of which was selected as the winner.” P1.*. Another way is that the municipality hires an engineering firm because: *”We don’t have the in-house capacity to design this ourselves. So, we went through the design process together with a bureau. In this case, it was a single-source procurement.” P7*. Also, the engineering firms could be asked to help because they can answer the question: *”What are the possible options?” P9.*

The hiring external firms has different advantages and disadvantages that were mentioned by the participants. External consultants often have stronger persuasive power towards internal stakeholders and departments, as mentioned by ”*But when an external party handles it, people in municipalities tend to accept it more readily, because those parties have a certain reputation or credibility.* P9. However, a disadvantage that was mentioned was that relying too heavily on external parties may lead to unnecessary costs. Some respondents warned that outsourcing should not become the default, especially when the municipality has sufficient in-house capabilities itself: ”*These are things we can actually do ourselves. We’re policy advisors for a reason, we’ve studied for this, so we’re capable of handling it ourselves. But nowadays, the standard response to everything is: “Just outsource it.” And the national government does that too, which only widens the gap in knowledge even further.”* P10.

Table 5.8: Overview of codes and frequencies tactic ”Solicitation”

Code	Number of times cited (N=5)
Benchmark	2
Innovation	2
Tender procedure	1
External consultant	4

5.1.4. Phase: Evaluation

In the ”Evaluation” phase, the potential solutions are compared to determine which option is the most suitable. The four main tactics of the ”Evaluation” phase are: ”Subjective”, ”Analysis”, ”Bargain”, and

”Judgment”. As can be seen in Table 5.1, the ”Bargain” and ”Analysis” tactic were identified most often. Interestingly, the ”Subjective” tactic did not occur and the ”Judgment” tactic occurred only once.

The most mentioned tactic is ”Analysis”. This tactic involves comparing alternatives using data, models, or performance indicators. This tactic is mentioned 8 out of 11 times in the interviews. The perceived influences of contextual factors on the ”Analysis” tactic are shown in Table 5.9 and Figure 5.1, column ”Evaluation”. The ”Analysis” tactic, involves using data to compare solutions, for example by evaluating whether they achieve the set goals and are effective, they do this by: *”if you make a sketch design for the entire planning area, a stress test must be carried out. To see: what happens to that area if 70 mm of rain falls? What is the effect on the urban heat island if you apply these measures in public or private space? So, the entire area is reviewed in this way.” P11*. The participants checked whether the ’”Objectives”’ they set in the ”Directions From” phase were met. An example is: ”*I just want to be able to demonstrate that the measures actually make sense. So I don’t even see that as particularly innovative, just: show that you’re doing it.” P11*. Furthermore, the the proposed measures had to fit within the available budget, as explained by *”It doesn’t fit, or it only fits at very high costs, because then you have to come up with expensive solutions. P5*”

Table 5.9: Overview of codes and frequencies tactic ”Analysis”

Code	Number of times cited (N=8)
Objectives	5
Budget	2

The second tactic that was mentioned often in the ”Evaluation” phase, is ”Bargain”. ”Bargain” refers to discussions and negotiations between stakeholders, such as internal departments or residents, to weigh and select among solutions. ”Bargain” is mentioned in 6 out of 11 interviews. The perceived influences are shown in Table 5.10 and in Figure 5.1, column ”Evaluation”. ”Bargain” can be carried out within the project team or between municipal departments. Within ”Bargain” trade-offs must be made. This supports an integral decision-making process, where climate adaptation goals are integrated with objectives from domains such as mobility or public space design. As explained by: *“This brings us to one of the most difficult points: all these disciplines bring their own goals to a project. We want trees, more parking, a heating network, water storage, new sewers, and so on. That all goes into one project.” P5*. Actually, this leads to problems as: *”As the design progresses, from concept to detailed design, you realize this doesn’t fit. Actually, you know from the start: if we want all of this, we’d need the space three times. It only fits if you apply very expensive solutions.” P5.* Residents can also be involved in the ”Bargain” process; this is often done via citizen participation. This is mentioned by: *“Then there is a consultation with residents to see what their wishes are and whether we can incorporate them.” P3* . But sometimes the wishes of the residents focus on mobility, leading to less climate change adaptation measures: *“During public consultation in another project, for example, we wanted to introduce one-way traffic to create more green space in the street. But residents didn’t want one-way traffic. So, we had to adjust and remove the green.” P3*. Budgetary considerations remain central in ”Bargain” tactic as well. As explained by the quote: *”We already involved them in the early phase to help make a decision. I believe we eventually developed three design options. These were presented to the project’s core team, who then decided: “Yes, this is financially feasible and fits within the project’s guidelines.” As a result, the water-retaining road was selected. We then issued a follow-up assignment to further develop that specific variant. ” P9.*

Table 5.10: Overview of codes and frequencies tactic ”Bargain”

Code	Number of times cited (N=6)
Budget	2
Integral decision	5
Citizen participation	2

The ”Bargain” tactic was mentioned four times in combination with the ”Analysis” tactic. In these cases Participants negotiated with residents and departments on what should be included in the project, after

which models are used to evaluate whether the discussed measures achieve the necessary outcomes. If not, a new round of ”Bargain” may take place to adjust the proposed measures. These newly proposed measures are then again evaluated via ”Analysis”.

The ”Judgment” tactic refers to situations where no clear justification is provided for the chosen solution. The decisions are based on curiosity, gut feeling, or implicit reasoning rather than on data, modeling, or structured analysis. This was only observed in 1 out of 11 interviews, in the second interview: *“There weren’t any in-depth studies conducted like: do we really need this or that?” P2A*

The ”Subjective” tactic involves assessment based on opinions, experience, or beliefs, often without relying on hard data. This tactic was mentioned 0 out of 11 times, none of the interviews revealed clear examples of this approach.

5.1.5. Phase: Implementation

The final phase identified by Nutt (2008) is ”Implementation”. The ”Implementation” phase emerges when a selected solution is put into practice. Tactics in the ”Implementation” phase are ”Edict”, ”Persuasion”, ”Participation”, and ”Intervention”. As can be seen in Figure 5.1 and Table 5.1 the ”Edict” and ”Persuasion” tactic were mentioned in four interviews. ”Intervention” was mentioned once and ”Participation” was mentioned 3 times.

The ”Edict” tactic reflects top-down, political decision-making. The ”Edict” tactic is applied when politics decide if climate change adaptation measures are implemented, which is shown in Figure 5.1 column ”Implementation”. 4 out of 11 participants describe such situations: *“In the end, it really becomes a political choice and that’s okay. As a civil servant, I won’t always win.” P4*.

In the ”Persuasion” tactic, civil servants aim to convince others, often higher-level decision-makers, by emphasizing the added value of a measure or aligning it with broader ambitions such as funding or quality criteria, which is seen in Figure 5.1, column ”Implementation”. This tactic was mentioned 4 out of 11 times. For example: *“We also sought funding through partners like X and X. That’s crucial in big projects, national or international subsidies are really valuable. When you have a subsidy, you can tell your administration: ‘Look, other parties are also interested and financially support this.’ That adds pressure on timing and decision-making, if we don’t act now, the subsidy’s gone.” P2*. Two influencing factors were identified. First, ”Persuasion” occurred when measures were implemented as part of an experiment, driven by curiosity to observe what the effects would be in practice. This is supported by: *”Then you notice that a city like X says: ’Yes, we just have to do this.’ And then costs are no longer really the deciding factor. It becomes more about seeing whether these kinds of principles can work in the city. The city’s administrators are informed about this.”* Second, some measures were highly technical and were implemented without participation, as their visible impact on residents was minimal. So, there were not many people that had a strong opinion on the project as explained by: *”The people don’t really notice much. What we actually do is disconnect, right? So a new pipe is placed next to the existing sewer pipe.”*

As shown in Table 5.1, the ”Participation” tactic was mentioned in 4 out of 11 interviews. Figure 5.1, column ”Implementation”, illustrates the contextual influences on this tactic. One example of the ”Participation” tactic is the integrative negotiation process that occurs within the project team and various municipal departments: *“There’s a whole process leading up to it. Eventually, it’s presented to the core project team, which gives the go-ahead. But then it still must go through the municipal process, the asset management department, finance, etc. All of them need to approve. Only then is it finalized.”* P9. The ”Participation” tactic often follows the ”Bargain” tactic from the ”Evaluation” phase. Within municipalities, different departments can express their views on a project. Implementation typically only proceeds once consensus is reached. The maintenance departments often play a crucial role in this phase. Because they are responsible for long-term upkeep, their approval significantly affects which measures are ultimately adopted. Climate change adaptation can alter how these departments operate, as many adaptation measures require more intensive or specialized maintenance. This poses a challenge, as it leads to higher maintenance costs.

The ”Intervention” tactic refers to implementing climate adaptation measures in response to external triggers—such as reports or complaints from the public. One participant described such a case: *“There were already objectives related to public space. But I do think it’s fair to say that the reports we received*

at that time contributed to us going ahead with the works." P7. These bottom-up signals generate urgency and can also be seen as a form of participation. However, the "Intervention" tactic was mentioned in only 1 of the 11 interviews, as can be seen in Table 5.1. Its contextual influences are shown in Figure 5.1, column "Implementation".

5.2. General perceptions of the influences

Now that the decision-making processes are and the context factors that influence different process steps are identified. The next Paragraph, discusses general factors that influence the entire decision-making process. An overview of the general themes that emerged is provided in Table 5.11.

Table 5.11: Overview of themes that influence the entire decision-making process

Theme	Mentioned (N = 13)	Example Quote
Practical challenges in the public space	12	*"Some choices were just, in terms of space use, not so smart in hindsight or not well thought through. So, you have neighborhoods in the Netherlands that basically lie in a kind of bathtub. You can install as much permeable paving as you want there, but that's just not going to solve the problem."* P8
Budget	12	*"We bring that together, then we take a broad look at the finances. Can we afford this? Do we have the money for it?"* P5
Municipal policy	13	*"The idea back then was to take a programmatic approach, because that would give us more oversight and allow us to use our resources more efficiently. Also, because you can only use a resource once." P7*
Organizational characteristics	10	*"So at municipality X, I think there are easily 10 FTEs working on this. But when I look at smaller municipalities, well, then it's literally someone who also handles the sewers. And climate adaptation is just part of their workload."*
Municipal politics	12	*"And there's also a degree of political consideration involved sometimes, right?" P5*
Participation	10	*"What kind of wishes do the residents even have?" P12*
Frame Green	12	*"I think the perception of a green living environment,that it is pleasant, not only supports climate adaptation goals but also contributes to other things."* P7
Frame Technical	11	*"You can enlarge sewer pipes, build storage facilities, or collect water."*
Responsibility	13	*"Of course, there are also many questions coming from the social domain, because when people have a large garden and a big, detached house, should the municipality also be planting trees in their front yard?" P8*
Risk perception & urgency	13	*"We have seen that change. They themselves are increasingly recognizing the necessity. Although they still find it difficult sometimes, like, how should we go about it? Especially in a high-rise city with densification. And there's already so much we have to do."* P5
Difficult to maintain	11	*"There is also always… From municipalities, of course, there's concern about maintenance. So okay, we're going to construct this wadi. That doesn't even have to be very expensive, but how do we ensure it continues to function properly?"* P8

Continued on next page

Table 5.11 – continued from previous page

Theme	Mentioned (N = 13)	Example Quote

5.2.1. Theme: Practical challenges in the public space

The most frequently named theme influencing the decision-making process was *practical challenges in the public space*. This theme was mentioned in twelve interviews, as is shown in Table 5.11 and emerged as a significant factor shaping decisions related to climate adaptation. The theme is composed of several subcategories, which are presented in Table 5.12.

The most often mentioned subcategory was environmental constraints. These are physical and legal boundaries like water levels, soil types, and existing infrastructure that set limits on what is possible in each location. These constraints create complexity that decision-makers must navigate. The issue of too little space is also a problem, particularly in older neighborhoods. These old neighborhood areas were originally built without climate adaptation in mind. Today, municipalities must choose between competing needs, such as mobility, parking, green infrastructure, and water resilience in these areas. The tension between these priorities often leaves little room for effective solutions. This tension intensifies further in vulnerable neighborhoods, especially those situated in low-lying areas or places with high groundwater levels. Here, the combination of outdated infrastructure, high population density, and limited budgets increases the challenge. Residents are dependent on municipal action, but decision-makers themselves are often unsure how best to respond. The type of soil also emerges as an important factor. The type of soil, such as clay or sandy soils and groundwater levels directly shape which adaptation measures are possible. For example, infiltration is only possible if the soil type is not clay and if the groundwater levels are not too high.

Yet, some participants described that space was no issue. For example, when redevelopment projects were described, there was sufficient space to implement adaptation measures. These instances show what is possible when spatial limitations are eased.

Table 5.12: Overview of codes and frequencies ”practical challenges in the public space”

Code	Number of times cited (N=13)
Environmental constraints	12
Lack of physical space	10
Problem areas	10
Soil type, groundwater levels	11
Measures dependent on location	5
Complexity of problems	6
Space enough	3

5.2.2. Theme: Budget

Municipalities face financial constraints, forcing decision-makers to balance ambition, quality, and cost. This often leads to the question: *”What level of risk are we willing to accept?”* a reflection of the trade-off between quality and affordability. Budget was cited in 12 interviews as a factor influencing the decision-making process, as is shown in Table 5.11. Table 5.13 summarizes the budget-related themes that emerged from the interviews and how often they were mentioned.

Limited budgets tend to reduce the ambition of climate adaptation measures. In some cases, there is no budget available at all. When there is no sense of urgency, redeveloping public space before infrastructure reaches the eol life is often considered as capital destruction. As a result, municipalities wait until the eol is reached before implementing any measures. Under budgetary pressure, this can lead to lower-quality decisions. Sometimes, the desired level of ambition simply cannot be achieved due

to financial limitations. Municipalities must first secure funding before any action can be taken. Dutch municipalities face budget cuts in 2025, due to the 'Ravijn jaar'. Climate change adaptation in this case is often seen as *"The one who pays the price." P3* and the first goal that is reduced upon. Budgetary considerations were mentioned frequently. Participants emphasized that, although they want to spend available funds wisely, resources are limited. As a result, difficult choices must be made.

On a more positive note, some participants reported having access to structural funding or their own budget for climate change adaptation. In these cases, funding was often drawn from sources such as sewerage levies, allowing for a more consistent integration of climate adaptation into planning. Similarly, access to national, provincial, or waterboard subsidies created room for additional climate change adaptation measures. These subsidies also enabled higher-quality adaptation measures. Often, such structural funding was made available after the municipality experienced an extreme rainfall event, which triggered political attention and a stronger sense of urgency. Some participants even reported having too much budget, which they cannot finish.

Table 5.13: Overview of codes and frequencies Budget

Code	Number of times cited (N=13)
Budgettairy considerations	12
Budgettairy constraints	6
Quality vs costs vs demands	7
Find budget	6
Own budget	5
Structural budget	5
capital destruction	3
Budgetary space	5
Too limited budget	3
Ravijn jaar	2
Low costs	1
Costs per M2	2
Subsidies	5

5.2.3. Theme: Municipal policy

The municipal policy approach strongly determines outcomes; municipal policy is mentioned in 13 interviews, as is shown in Table 5.11. An overview of the subcategories is provided in Table 5.14. When a municipality adopts a strategy of linking climate change adaptation to existing projects, this often leads to fewer standalone climate change adaptation measures. This is because the roads are only redone approximately once every forty years and the sewing system is redone once every hundred years. Often when project coupling is in place all goals across the municipality are assessed via integrated objectives and planning. Integration of projects can turn out positive or negative. Integration increases project coherence. While it can also lead to contrasting priorities, often at the expense of climate adaptation when budget pressures or spatial constraints arise. In contrast, when municipalities allow for independent climate adaptation initiatives, more action tends to follow. Then projects might start from climate change adaptation needs in areas that face a high risk. Sometimes even in these cases the street is open before it is even necessary because the objects are eol. A hybrid version also an option, in this case the very high risk areas are independent projects and the high and moderate risks are done via project coupling. This choice is often made by municipal politics because of budgetary limitations.

Within the water section, often municipalities try to work towards a future goal. Working and redeveloping towards a future goal influences whether and how climate adaptation is implemented in municipal projects. Long-term visions can provide direction, but targets need to be accompanied by clear obligations and goals. Otherwise, they risk remaining symbolic.

Table 5.14: Overview of codes and frequencies ”Municipal policy”

Code	Number of times cited (N=13)
Integration	10
Future goals	10
Project planning	7
Programmatic approach	7
Planning	5
Policy decision making	8
Couple to other projets	9
Do projects earlier than eol	4

5.2.4. Theme: Organizational characteristics

Not every municipality is the same. As one participant noted: *”I think it’s especially important to be critical and ask: have I spoken to both a large and a small municipality, and have I included municipalities from the west, east, north, and south? Because climate-related problems are, of course, different across regions. Some issues apply everywhere, but there are definitely local problems as well. Land subsidence isn’t a problem in all of the Netherlands, and drought isn’t either. So, I think it’s interesting to make that distinction.” P8*. As can be seen in Table 5.11, ten participants mentioned that organizational characteristics had an influence on climate change adaptation, an overview of the subcategories is provided in Table 5.15.

Differences between small, medium sized and large municipalities play a role in how climate adaptation is organized. Large municipalities often struggle with internal fragmentation, making coordination across departments and the allocation of responsibilities challenging. Communication gaps further hinder progress. At the same time, fragmented or inconsistent policy is seen as a barrier in large municipalities. As explained by: ”*This is really a challenge in large organizations. Knowledge sharing is very complex. What you see is that, I think, X carries out hundreds of projects a year. All of these are evaluated, but who actually attends those evaluations? And there are dozens of projects with facade gardens, and neighborhood actions in 14 districts. Of course, the people in the neighborhood teams talk to each other, but the question is whether the strategists really know what’s happening there and how it’s going. P2”* Compared to small and medium sized municipalities where: ”*In small or medium-sized municipalities, people are much more closely involved, so it’s easier to pick up on what’s going on.” P1*.

However, small municipalities face capacity issues. Climate adaptation is often one of many competing tasks assigned to a single staff member, which is also noted: *“Secondly, some of the municipalities are just very small. So, you have a climate adaptation officer who also has to deal with many other domains. And then, I think, it simply gets de-prioritized.” P13*. Nevertheless, when a motivated and capable individual is present, smaller municipalities can be surprisingly agile and innovative. Their short lines of communication and informal structure can accelerate experimentation and implementation. “*But what’s interesting about small municipalities is that if someone is intrinsically motivated to work on climate adaptation and if the organizational culture supports that, then you often see that small municipalities can achieve a lot. Because the organization is so compact, the influence of a single individual can be much greater.” P2*

Municipalities of different sizes were interviewed. Seven large municipalities, one small municipality and four medium-sized municipalities were interviewed. Interestingly, a notable pattern that emerged is the variation in tactics used by small & medium municipalities versus large municipalities. An overview is provided in Appendix E.

For instance, the ”problem” tactic from the ”Directions From” phase was mentioned only once among medium and small municipalities, while it appeared three times in large municipalities. This suggests that larger municipalities may be more inclined to base their actions on problem analyses. Similarly, the ”innovation” tactic from the ”solutions found by” phase was cited four times by large municipalities, but only once by a small municipality, suggesting a greater capacity or willingness to experiment in larger

organizational settings.

The ”Analysis” tactic from the ”Evaluation” phase was used in five out of seven large municipalities, but only three times in small and medium-sized ones, suggesting that analytical approaches are more deeply embedded in the decision-making routines of large municipalities. Furthermore, the ”Bargain” tactic in the ”Evaluation” phase also appeared more often in large municipalities (4 mentions) than in small and medium municipalities (2 mentions), reflecting the more complex stakeholder environments in larger urban settings where negotiation plays a bigger role in shaping outcomes.

The ”Edict” tactic from the ”implementation” phase was not mentioned at all in small and medium municipalities, yet it was the most frequently cited tactic in large municipalities. This suggests that top-down decision making is prevalent or accepted in larger municipal organizations, possibly due to their more layered hierarchies.

Table 5.15: Overview of codes and frequencies ”Organizational characteristics”

Code	Number of times cited (N=13)
Big municipalities	5
Small municipalities	4
Knowledge sharing	7
Layers in structure of municipality	4
Limited knowledge	2
Capacity problems	2
Medium sized municipalities	3

5.2.5. Theme: Municipal politics

Close to municipal structure is municipal politics. Political influence was mentioned as a factor of influence in 12 interviews, shown in Table 5.11. An overview of the subcategories is provided in Table 5.16.

Municipal politics plays a role in determining the extent to which climate adaptation is prioritized. Often it is a political choice what the budgets are, how much space there is for climate change adaptation, and what objectives receive priority. The color of the parties that are in the municipal council determines the priority for climate change adaptation. Politicians often think about what the residents want to gain electoral support, when they are making a choice. Explained by: *”The city council said beforehand: ’If the Neighborhoods do not want a creek, then we will not implement a creek.’” P12.*

Table 5.16: overview of codes and frequencies ”Municipal politics”

Code	Number of times cited (N=13)
Political choice	11
Political responsibility	7
Political party choice	7
Support from local politics	7
Political sensitive	2

5.2.6. Theme: Participation

Citizen participation was mentioned to have an influence in 10 interviews, as is shown in Table 5.11. The subcategories are visualized in Table 5.17. Citizen participation is mandatory in all municipalities in the Netherlands and the way participation is shaped, can range from selecting preferred options to actively shaping spatial layouts, based on the Ladder of Participation in the Netherlands, which is explained in Paragraph 2.1. Often participation is shaped in a way that the municipality tries to listen to the residents’ wishes.

Participation has positive and negative sides that are perceived by the participants. Some intervie-

wees described participation as frustrating, particularly when residents lack technical knowledge but still heavily influence outcomes. This is especially the case when politicians side with them to safeguard support for the elections. When residents are asked to prioritize within limited space, they often choose options such as parking or mobility infrastructure over climate change adaptation measures, particularly in spatially constrained areas. This is because awareness for climate risks remains limited. A recurring pattern in these cases is that citizen participation, while intended to increase legitimacy, can lead to the exclusion of climate adaptation measures. On the other hand, well-designed participation processes can lead to greater public support, particularly when there is awareness of climate risks. Effective participation requires that residents understand the trade-offs municipalities face and feel involved in decision-making. Citizen participation in some municipalities structured in the form of a residential committee. The goal of this committee is show the other residents the importance of climate change adaptation and how they can become more climate adaptive themselves. These committees help raise awareness and are also more convincing than the municipality.

Table 5.17: Overview of codes and frequencies ”Participation”

Code	Number of times cited (N=13)
Listening to residents	7
Participation positive	5
Participation negative	7
Participation general	3
Resident involvement	4
Communication with residents	5

5.2.7. Theme: Frame green vs technical measures

The way climate adaptation is framed also influences outcomes. A technical frame often leads to less enthusiasm and less support. Technical limitations can reinforce perceptions that the problems are unsolvable or too costly. Particularly when they do not visibly enhance the public space. Conversely, framing climate adaptation to improve quality of life, add green space, or increase urban value can generate greater support among citizens and politicians. The consideration between technical measures compared to green measures is mentioned in 5 interviews.

Adding green is mentioned as a solution in 12 of the interviews. Subcategories are provided in Table 5.18. While there is no consensus on its effectiveness in reducing the direct impacts of extreme precipitation, many participants note its broader benefits. Some suggest that green measures alone may have a limited impact on mitigating heavy rainfall. However, the added value of greenery lies in its multi-functionality. Green infrastructure helps reduce heat stress by cooling urban areas and improves quality of life. One interviewee noted: “*A green square with a wadi in it, that’s not only climate-adaptive, it’s also good for recreation, for social interaction… for the value of your home, so to speak.”* P8. This highlights how green spaces contribute to a more livable and pleasant environment. Participants also emphasized that such interventions could enhance spatial quality and even raise the value of houses.

These broader benefits suggest that green solutions should not be evaluated solely by their technical performance, but also by their social, environmental, and economic contributions. These extra contributions also help in finding public support for climate change adaptation. This is noted by: *”So we could’ve solved this in a completely different way, right? I mean, yeah… I can look up what the exact requirements were, but let’s say the requirement was to be able to store 50 mm of water or something like that. Sure, we could’ve handled that in a purely technical way, but we deliberately chose to give it an additional function as well.” P1.*

Technical solutions have been mentioned in the interviews 11 times, as shown in Table 5.11. The subcategories are shown in Table 5.19. Also on technical measures, suggested is that their effect is limited. Several participants expressed skepticism about the effectiveness of measures like disconnection or local storage, especially under increasingly severe weather conditions. This perceived limited effect is explained by: *“We researched whether disconnecting rainwater would reduce flooding. The effect was minimal. We later added an overflow and increased the culvert’s capacity to allow water to drain*

Table 5.18: Overview of codes and frequencies ”Frame: green”

Code	Number of times cited (N=13)
Heat stress	7
Greening	8
Create a nice living environment	4
Add value	2
Couple to green	4

more easily into surface water. That helped a little, but the sewer is designed for 20 to 30 mm of rain, while flooding occurs at 60 to 100 mm.” P3. Of course, if you pay a lot of money, it is possible to solve everything. But often the budgets are not high enough and then it becomes a question of what risk is acceptable?

Table 5.19: Overview of codes and frequencies ”Frame: technical”

Code	Number of times cited (N=13)
Effectivity of technical measures	7
Technical knowledge	5
Technical solutions	4
Technical goals	2
Feasibility	2

5.2.8. Theme: Responsibility

Questions about responsibility were mentioned 13 times as perceiving to effect the implementation of climate change adaptation, as is shown in Table 5.11. The subcategories are shown in Table 5.20.

Municipalities often point to private responsibilities, such as the impact of paved gardens. In some cases, municipalities are unable to resolve problems due to physical constraints, such as low-lying homes. Participants perceive a discrepancy between expectations from residents and practical feasibility when it comes to water safety during extreme rainfall events. One interviewee reflected: *“Everyone always says in these kinds of situations: water on the street is acceptable, but not in homes. I fully agree, but I’m not going to guarantee that. I live in a street with about 20 meters of elevation drop over 200 meters. That water just rushes down and hits the building straight on. I can’t do anything about that.” P5*.

Additionally, private entities such as housing corporations and developers play a role. Municipalities can impose requirements on water retention or drainage, but only if these are clearly embedded in zoning plans. It is important that municipalities bring in these requirements, because if they do not do so: ”*And so, the municipality has a major role to play in implementing this in public space, while developers have a big responsibility to take action on and around their properties. Yeah, and I think it always must come from both sides. But the municipality does have a particularly important role here, because they’re the ones who need to set the requirements. Few developers will take the initiative on their own. So, when you’re talking about decision-making, it really starts with the municipality taking the lead. And they can take that role.*”P1. The interviews showed that municipalities do not often take this role and point towards private responsibility, not only of developers and corporations, but also of the residents: ”*Yeah, but I also have to say that where there’s still real progress to be made is in encouraging more people to take action themselves. For example, we formed a working group of residents who help think along and contribute to the neighborhood plan. And then you start discussing: what can you actually do yourself? Often, people, residents, see their role mainly as advising the municipality, as if the municipality is the one that has to do everything. And I say, that’s fine, but in the end, you also have to act. We need to get to work, and I want that, but while you do see some initiatives, it’s still lagging a bit, in my opinion.*” P6. Of course, the municipality can make the public space climate change adaptive, but if the private space remains unprepared for climate change, problems keep occurring.

Furthermore, tensions arise between municipalities and water authorities, whose technical requirements are often designed for rural contexts. Which are not always applicable in urban areas.

Table 5.20: Overview of codes and frequencies "Responsibility"

Code	Number of times cited (N=13)
Private Responsibility	10
Unclear responsibility	5
Responsibility waterboard	5
Responsibility municipality	3
Responsibility central government	1

5.2.9. Theme: Risk perception and Urgency

Table 5.11 shows, that thirteen participants indicate that the perceived urgency and risk of climate change varies and significantly influences decision-making and public support. One respondent explains: *"People notice issues like roads becoming impassable or puddles so deep you can't get into your car, even if entire houses don't flood. It's about perception, our threshold is 20 to 30 cm of standing water, which is extreme, but residents experience smaller-scale nuisance."* P6. The subcategories are shown in Table 5.21.

Perceived urgency increases after an extreme event, this motivates action. When extreme events occur, they create momentum that facilitates implementation: "*After heavy rainfall causing local flooding, there is media attention and political pressure, making it easier to allocate funds for adaptation measures. If such events do not happen for a while, attention and support tend to fade."* However, generating sustained incentive remains challenging because many climate adaptation measures do not yield immediate, tangible benefits for residents. For example, one participant notes: *"People often ask what a green roof brings them. Unlike solar panels, which have direct financial returns, green roofs mainly provide insulation but don't offer immediate monetary gain. It's like buying a new jacket, you don't expect it to pay off financially, but it adds value in other ways." P1*.

Despite this, awareness has increased over the past decade, and climate-related requirements are now more common in building projects. Still, skepticism remains, especially in areas that have not yet experienced severe flooding: *"We try to explain that while a 1-in-100-year rainfall event seems unlikely, it can happen tomorrow, and the chances are increasing with climate change. Convincing residents, and sometimes even internal staff like sewer managers who rely on older rainfall models, is an ongoing challenge."* P6. This is also shown by: *"In terms of climate adaptation, there's really nothing you can do there. But it is an area prone to flooding. So when it rains, houses get flooded. What can you do? Yet people still want to park there. They say, 'I've lived here for ten years, and it's never happened.' Sure, it's a one-in-a-hundred-year event, but it could happen tomorrow, and then again soon after. So it's difficult." P11*.

Another difficulty is that many areas in a municipality face a high risk of climate change and require climate change adaptive measures. For municipalities the question is often: 'where do you start in public space?' Municipalities find different solutions for this. Some use the label systematic, other municipalities define acceptable risks, and categories, such as very high risk, high risk, medium risk and low risk. The very high-risk areas get alone standing measures, while for the high risks they are waiting for couple opportunities. The low and medium risks are considered acceptable. Which is explained by: *"After that, we started working with risk-based management. In short, this means that we assess the effects, risks, and likelihood of occurrence to determine the risk of a particular event." P12*.

5.2.10. Theme: Difficult to Maintain

As is shown in Table 5.11, a frequently mentioned barrier perceived to influence implementing climate adaptation measures is maintenance, this is mentioned in 11 interviews. Many adaptive solutions are unfamiliar to traditional maintenance departments and require more frequent or specialized maintenance than conventional systems. Public space maintenance and management influence the long-term

Table 5.21: Overview of codes and frequencies perceptions of ”Risk & urgency”

Code	Number of times cited (N=13)
Awareness	5
Urgency	8
Investment vs risk	3
Communicating risk	3
Risk perception	4
Risk locations	2
Prioritizing	6

maintenance responsibilities of departments; these influence which solutions are implemented. If maintenance is deemed too complex or costly, measures are often reconsidered or scaled down. *”Often the biggest sticking point in a municipality, is maintenance. Because maintenance is used to… well, to exaggerate a bit, but historically, it was always about sewer systems. Maybe one big tank: okay, we flush the sewer, clean the tank, and that’s it. And now suddenly they have to maintain a wadi. Or a water-retaining foundation. How do you do that? How do we access it? How are we going to manage that? These kinds of questions are where it often breaks down.”* The frequency and cost of maintenance are also problematic: *”Look, with a sewer, you might come by once every two to five years. But with a wadi, you may have to check it every six months. That also has financial implications. And those costs have to come from somewhere, so it quickly becomes an issue.”* This is especially a problem when dealing with innovative, decentralized, or nature-based solutions that fall outside conventional maintenance practices.

6

Discussion

The Discussion reflects on the main findings of this thesis and positions them within the context of existing literature on climate change adaptation and decision-making processes. The aim was to analyze what the results meant for theory, policy, and practice. In doing so, the discussion addresses both the contributions, the limitations and the future research directions of this thesis.

The Discussion chapter starts with interpreting the decision-making processes in climate change adaptation in Paragraph 6.1. Paragraph 6.2 gives the interpretation on the general influencing factors on the process. Paragraph 6.3 discusses the limitations of the research and based on this the directions for future research are provided.

6.1. Decision-making processes in climate change adaptation and their perceived influences

The results of this research show that the Nutt (2008) framework can generally be used to describe decision-making processes. Although in some cases, multiple decision-making tactics were used within one decision-making phase. In practice, this indicates a more layered process than the Nutt (2008) framework describes and may interact dynamically. This is in line with the definition of a decision-making process by Mintzberg et al. (1976), who suggests it is a dynamic interaction of factors. This is illustrated by the “intelligence gathering phase” where the ”Needs” tactic often followed the ”Opportunity” tactic, instead of being a separate tactic. Municipalities may recognize climate risks (”Opportunity”) but only act once political or societal urgency is made clear (need). For one municipality the central government obliged them to do stress tests, but because they have no experience with extreme weather events, the maintenance department and the local politics do not feel the urgency to implement measures. This is in line with Bellmann et al. (2025), who shows that obligations from the central government are not enough to incentivize action, as there is also a need for experience that shows why action is necessary. Similarly, in the ”Directions from Phase” the ”problem” tactic was only mentioned in combination with the ”Objectives” tactic. This dual approach involved the structural use of a model to identify issues and then translate them into goals. This illustrates a more rational, evidence-based style of decision-making, such as system 2 (Orlove et al., 2020). While other researchers have emphasized the importance of systems 1 and 2 (Orlove et al., 2020; Siders & Pierce, 2021), the analysis of this research showed that tactics with characteristics connected to system 2 decision-making were utilized in these cases. However, the use of system 2 also revealed practical barriers: even when a problem and corresponding goal are clearly defined, municipalities often lack the resources or face spatial limitations to implement the full scope of measures needed. An example of this was the ”labeling systematics” used by municipalities. Here the goals were systematically defined, but practical challenges hampered effective implementation. Often when the ”Objectives” were defined in the ”directions from phase” in the ”Evaluation” phase the ”Analysis” tactic emerged, to check if the prescribed measures reached their intended ”objectives”. Notably, in the ”Evaluation phase” the ”Analysis” tactic was also often combined with the ”bargaining” tactic. In these cases, models and quantitative evaluation were combined with

negotiation in the municipality, often combining integral objectives. Overall the results highlighted that evaluation in climate change adaptation decision-making is increasingly structured, data-informed, and negotiated, rather than intuition-based. This reflects a tendency towards structured system 2 decisions (Orlove et al., 2020; Siders and Pierce, 2021). Another combination of tactics was observed in the ”solutions found by” phase, here the ”Solicitation” tactic was combined with the ”Innovation” tactic or the ”Benchmark” tactic. External parties tend to be more informed in what innovations are going on and what successful approaches are adopted in other municipalities.

Notable is also that the results show that different tactics were exclusively used in large municipalities, while others were exclusively used in small/medium sized municipalities, as further outlined below. This reflects differences in climate change adaptation governance between large, medium, and small municipalities. For example, in the ”Directions from” phase the ”problem” tactic, in the ”Solutions found by” phase the ”Innovation” tactic and in the ”Evaluation” phase the ”Analysis” tactic, were mainly observed in large municipalities. Also, specific goals in the ”Objectives” tactic of the ”Directions from” phase where mainly defined by large municipalities. An explanation is that large municipalities have more capacity and access to spatial data. Therefore, they have more access to models and informed decision-making. It could also be explained by the fact that large municipalities have more formalized processes that need specific goals that are researched. This thought is supported by the fact that the ”Edict” tactic in the ”implementation” phase was only used in large municipalities, as the ”Edict” tactic involves top-down political decision-making. Suggested is that evidence must be provided before the Political decision is made. The presence of the ”Edict” tactic showed the importance of political attention for climate change adaptation plans. However, the absence of this tactic in small and medium-sized municipalities may indicate a less formalized or less politicized governance culture. Furthermore, small and medium sized municipalities tended to formulate broad intentions in the ”objectives” tactic of the ”directions from” phase. Also, in the ”Solutions found by” phase, the Idea tactic, or standardization was mainly used in small and medium-sized municipalities. This finding underscores a practical preference when the effectiveness of solutions is known and easy to maintain. Standardized approaches may limit the effectiveness of climate measures in different contexts. This tactic is also defined as unsuccessful by Nutt (2008). The reason for using standardized approaches might be capacity limitations. Capacity limitations is also a reason why ”Solicitation” tactic is observed for the ”solutions found by phase” in Small and medium sized municipalities. Although in combination with solicitation, innovation is observed in small and medium sized municipalities. On the other hand, small and medium sized municipalities appeared more hesitant in implementing innovative ideas, often delaying decisions to wait and see the performance of the new technologies in other municipalities, this is reflected by the ”Benchmark” tactic of the ”solutions found by phase”.

Regarding the phases of the Nutt (2008) framework, interesting insights emerged in each phase, which are discussed next. In the **Intelligence gathering phase**, the ”Opportunity” tactic was mentioned most often, although according to Nutt (2008) it is not a successful tactic. The ”Opportunity” tactic was mentioned frequently due to the mandatory stress tests that municipality had to conduct. Although the stress test alone was not the only reason why a project started and was implemented successfully. So, in addition to a stress test another ”Needs” or ”Opportunity” is a necessary incentive. Using an ”Opportunity” tactic means that climate adaptation is often approached in a pragmatic and reactive manner. Municipalities tend to wait for opportunities to integrate climate measures into existing or upcoming infrastructure projects. This suggests that decision-makers often seek low-resistance paths, especially when large investments are required. However, the heavy reliance on coinciding projects implies that adaptation may be significantly delayed, sometimes by decades. This raises questions whether municipalities have sufficient awareness about the urgency of effective climate change adaptation measures. The ”Needs” tactic in the ”intelligence gathering phase” is considered successful according to Nutt (2008). The ”Needs” tactic is often triggered by extreme weather events or visible degradation of public space. This tactic played a key role in converting awareness into political urgency. The combination of an experience with extreme weather hence attention for the impacts, appears to function as a driver for action. This can be seen as a reactive decision-making process, where action tends to follow a crisis or public pressure. This finding is in line with other studies on climate adaptation, which argue that municipalities are more likely to act after experiencing climate-related disruptions (Amundsen et al., 2010; Arnbjerg-Nielsen et al., 2015; Madsen et al., 2019). Research in psychology following a flooding event also supports the finding that experiencing flooding can lead to support for mitigation policies

and climate change adaptation measures that extend beyond the direct experience itself (Demski et al., 2017). Also, individuals that have an experience with a flood tend to have more support for policy on climate change adaptation (Ray et al., 2017). The findings of the intelligence gathering phase expose a critical dependency on coincidence or crisis in local adaptation policy in the Netherlands. While coupling is practical, it leaves municipalities vulnerable to delays and is not a proactive strategic approach. A shift toward more structured, forward-looking planning may be needed to ensure timely adaptation. Especially since, because climate change is happening, the risks become even bigger. In summary, ”Opportunities” arise often when climate change adaptation is not a prioritization, ”Needs” arise when experience with extreme rainfall has led to damage, and the urgency is clear.

In the **directions from phase**, municipalities define and pursue their direction when addressing climate change adaptation. In almost all municipalities the ”Objectives” tactic emerged, which is successful according to Nutt (2008). Notably, while Nutt (2008) treats all ”Objectives” equally, the interviews revealed a wide range of objective types. The findings of this research show very different types of ”Objectives”, ranging from stating ’we want to maximize the objectives’ to ’we want to capture 50 mm of precipitation’. This difference matters. Quantitative objectives can be tested and validated in the evaluation phase, making it easier to assess its impact. In contrast, abstract goals are harder to measure and less likely to guide effective decision-making. This aligns with existing literature that suggests that defining clear KPIs is a key driver for climate adaptation (Díaz et al., 2024; Simonet & Leseur, 2019; Temby et al., 2016). Although it was noted that some adaptation goals are not realistically achievable within the constraints of space and budget. Even when indicators point to obvious solutions, such as planting more trees, the feasibility of doing so is not always considered. This can create frustration and misalignment between strategic planning and practical execution. Notably, the ”Idea” tactic was rarely used. This may indicate that idea-driven decision-making is rare for Dutch municipal climate change adaptation decisions, this might be explained by the high costs that come with these measures, and therefore require more justification. However, in the specific case that the idea tactic was mentioned, it appeared interesting, because it demonstrated how internal enthusiasm and informal coalitions across municipal departments can have a decisive influence. This supports the notion that leaders within organizations can create a drive to implement climate change adaptations (Roberts, 2008). Together, these findings highlight that while municipalities may follow similar tactical frameworks, the way they define their goals plays an important role for effectiveness of their adaptation efforts.

The next step, in the decision-making process was when municipalities determined how to find suitable solutions. This was reflected in the **solutions found by phase**, where different tactics were used. The ”Idea” tactic and the ”Benchmark” tactic reflect a low-risk, imitative approach. By replicating measures seen in other municipalities or standardization, organizations mitigate the uncertainty about effectiveness. These tactics may unintentionally discourage innovation. Also noted was that solutions that are successful elsewhere may not always translate effectively to different contexts (Roders & Straub, 2015; Schoenefeld et al., 2023). The ”Benchmark” and ”idea” tactic often emerge when a municipality has limited capacity (Simonet & Leseur, 2019; Temby et al., 2016). Also, the ”solicitation” tactic emerges when a municipality has limited capacity (Simonet & Leseur, 2019; Temby et al., 2016). ”Solicitation” was observed both in large-scale tender processes and in projects that involved engineering firms. At the same time, ”Solicitation” was seen as a successful tactic according to Nutt (2008), as they can generate more innovative ideas. However, ”Solicitation” might lead to municipalities being dependent on costly external expertise rather than building their own knowledge. This leads knowledge draining and municipalities that become less flexible. Literature also underscores that bureaucrats sometimes have limited expertise (Simonet & Leseur, 2019). Finally, the ”Innovation” tactic was primarily observed cases that highlighted a willingness to experiment, push boundaries, and test novel techniques. Nonetheless, municipalities see the practical constraints of ”Innovation”, which are maintenance concerns, technical uncertainties, and the dynamic evolution of technologies. In summary, the way municipalities shape the ”Solutions found by” phase is dependent on their willingness to take risks and their internal capacity.

The **evaluation phase** showed how municipalities evaluated their proposed solutions. The ”evaluation phase” showed that this could be structured either by using models and/or negotiation between departments. The ”Bargain” tactic reflects the municipal integral way of working. Municipalities often face conflicting spatial and functional demands. ”Bargaining” helped to balance these interests, across departments and with the residents. The analysis revealed how inter-departmental negotiations and citizen participation shape climate change adaptation measures that face space constraints. But when

the urgency of climate change adaptation was limited, ”Bargain” could lead to reduced ambitions, because the other goals of the municipality will then be prioritized over adaptation. However, while the integral or sectoral way of working was often mentioned in interviews, the literature does not name this as an influencing factor. The second tactic that frequently emerged was the ”Analysis” tactic. Analytical evaluation allows municipalities to simulate and compare alternative solutions using models, maps or stress tests. This approach facilitates transparency and enables decision-makers to justify their choices based on KPI’s (Díaz et al., 2024). According to Nutt (2008) this was a successful tactic for decision making.

After evaluation, the decision must be made for the solutions to be implemented. This was reflected in the final phase of the Nutt (2008) framework; the **Implementation phase**. Within the ”implementation phase”, the ”Persuasion” tactic reflects the strategic framing that policy makers apply to build a momentum for implementation of measures and to highlight the benefits of their plans. This aligns with insights from the multiple streams framework (Kingdon, 1984). ”Persuasion” thus acts as a bridge between bureaucratic planning, timing, and political execution. The ”Participation” tactic was another common tactic and was considered successful according to (Nutt, 2008). The implementation process often proceeds through involving internal departments, project teams, and external stakeholders, that all have to approve. This tactic illustrated how horizontal coordination are necessary to move from plans to action. However, this approach was also slow and dependent on internal alignment. The ”Intervention” tactic, while less frequently mentioned, highlighted the responsive nature of implementation. This tactic shows how external triggers can push municipalities to act, even when no formal implementation plan was yet in place. It reveals a degree of adaptive capacity, where municipalities respond opportunistically to problems. Reasons why this tactic was less frequently mentioned could be that residents do not know what climate change adaptation is and do not know that they could notify the municipality when they face nuisance. The ”Edict” tactic involves top-down political decision-making. It aligns with the research of Roberts (2008), that political leaders can stimulate climate change adaptation. However, ”Edict” is not considered a successful decision-making method according to Nutt (2008).

6.2. General context factors interpretation

Besides the Nutt (2008) tactics and their specific influences on each process phase, there are certain context factors that participants perceive to have an influence on decision-making for climate change adaptation, according to the perceptions of the interview participants. These general influences decide whether the ambition of climate change adaptation can be made true in municipal projects.

The first and mostly named influence is ”**practical challenges in the public space**”. This entails limitations in the public space and the physical environment, which makes it difficult to implement climate change adaptation measures and integrate them into existing structures. This was mainly a problem in the older and vulnerable areas where the implementation of climate change adaptation measures was important. Although in the literature study this factor was not yet found to influence climate change adaptation. Innovative solutions might help to solve these problems.

But when innovative climate change adaptation measures are chosen the ”**maintenance**” departments wants to ensure that the maintainability of the measures was easy and affordable. New solutions present challenges for municipalities, particularly regarding long-term maintainability. Many maintenance departments are still oriented towards traditional infrastructure, like sewer systems, which require less frequent and more familiar and standardized upkeep. Innovative solutions, such as wadi systems or water-retaining foundations, demand more regular checks and specialized knowledge, leading to operational and financial friction. This gap between ambition and implementation capacity was perceived as a critical barrier but not mentioned in the literature.

Both the maintenance and practical challenges could be solved with enough budget. If there were no budget restraints very innovative measures could be implemented and maintained. But ”**Budget**” limitations was an important reason why climate change adaptation measures are not often implemented in municipalities. This holds several implications. First, if there was no structural financing there are less climate change adaptation decisions that are being implemented. According to the participants, external funding, such as a subsidy, might lead to the implementation climate change adaptation, which was mentioned in the literature by Dilling et al. (2017) as well. Furthermore, the height of the subsidy de-

termines the ambition and the effectiveness of the measures. Furthermore, the consideration between budget and willingness to accept risk was mentioned in the interviews. Opening the street earlier than the eol of the object was seen as capital destruction, even if that street faces a high risk of flooding. Some municipalities look at the possibilities to use every euro budget as efficiently as possible.

The choices of budget allocation and the considerations of what received priority in the public space, often has to do with ”**organizational characteristics**”. Factors that fall within this theme are **policy, political, and organizational factors**. The decision that coupling opportunities are the only reason for climate change adaptation lies with the municipal politics. For example, the choice of coupling climate change adaptation to regular projects could lead to more adaptation if these projects are done in the short term. But if the timeline for the projects was very long or not clear yet, it could also limit climate change adaptation. In the literature this was described as a conflict between long term climate change impacts and short-term political agendas (Simonet & Leseur, 2019). Integrating climate change adaptation goals with the goals of other departments, might even lead to reduced implementation, because when there was a need to make choices, climate change adaptation was the first thing to be reduced upon. Furthermore, limited political drive was a barrier to adaptation (Dilling et al., 2017; Oulahen et al., 2018; Simonet & Leseur, 2019), while in contrast a political leader can stimulate adaptation (Roberts, 2008). Municipal politics decides the budget allocations for climate change adaptation. They also make the decisions on what goals receive priority in public space. Often goals for parking and climate change adaptation clash. Then the decision on what goals receive prioritization is a political decision. Political factors and choices were often mentioned as a reason why adaptation was or was not implemented.

The political choice for parking instead of climate change adaptation, or the political choice to wait for coupling opportunities, was in line with the **”urgency and risk perception”** theme. Perceived ”urgency” and ”risk perception”, strongly influence climate adaptation decisions. The theme urgency and risk perception entail that people (bureaucrats, politicians or residents) are more likely to support measures when they experience visible disruptions rather than abstract risks. This was in line with literature findings: after extreme weather events, urgency spikes, making political and financial support easier to secure (Lindell & Perry, 2011; Wolf et al., 2021). However, this momentum was often short-lived, especially since out of the analysis it was mentioned that many adaptation measures offer no immediate personal benefits. Analysis also found that skepticism remains a barrier, especially in areas that haven’t experienced severe flooding (Lindell & Perry, 2011; Wolf et al., 2021). Even within municipalities, outdated models and internal resistance complicate the progress. Prioritizing adaptation is another challenge, as many areas within the municipality face urgent needs. Some municipalities use risk-based approaches to categorize threats and allocate resources more strategically, which was also explained as a driver for adaptation (Fatti & Vogel, 2011).

Municipalities recognize the risks of climate change, but they only act once the political or societal urgency was made clear. But, besides waiting for an extreme precipitation event, municipalities could also create urgency by coupling climate change adaptation measures to add value. The theme **”framing”** reflects this tendency. Green environment, health and added quality are effective frames to realize climate change adaptation measures. Acknowledged by the Literature that states that the perceived use for other purposes is important (Lindell & Perry, 2011; Wolf et al., 2021). When climate change adaptation measures are usable for another purpose, this might lead to support from the public and local politics. A disadvantage of green is that the effectiveness of the measures is perceived as limited by many participants. Implementing measures that are very effective impose high costs for the municipality

Besides limited urgency, ambiguity around **”responsibilities”** is a key barrier to the implementation of climate adaptation measures. This has also been observed in adaptation studies (Schoenefeld et al., 2023). However, these studies focused on structural aspects. Municipalities recognize their central role in shaping public space, yet they often point to private actors as equally responsible for their own property. These private actors oppositely point to the municipality as they expect that the municipality can solve all the problems.

Private awareness and responsibility can be increased via involving local communities. In the literature review, was suggested that there is too little involvement of the local communities (Azhoni et al., 2017; Dilling et al., 2017; Oulahen et al., 2018; Roders & Straub, 2015; Schoenefeld et al., 2023), while in the analysis, the ”**participation**” theme came forward as a very prominent factor in climate change adap-

tation decisions. Although the effect of participation and involving the public was no consensus on. On the one hand, participation creates support and awareness; on the other hand, it may involve residents who lack sufficient knowledge of the problem or awareness of the risks they face. When there was limited space, residents tend to prefer mobility or parking instead instead of climate change adaptation. This reflects on the theme urgency and risk perception, as lack of awareness was also mentioned as a problem in the literature (Azhoni et al., 2017; Dilling et al., 2017; Oulahen et al., 2018). The reason why participation was a prominent theme in the analysis, could have to do with the Netherlands governing structure. As in the Netherlands participation is mandatory, but how the participation is structured can be decided by the governing body itself (VNG, 2023).

6.3. Limitations & Future research

Although data collection and analyses has been executed with the greatest thoroughness, there are always limitations due to different factors. It is important to indicate these limitations, to be able to signify the contribution of this research. Based on the limitations suggestions for future research are made.

The first limitation of the research was bias, which may arise if the interviewer asks biased questions or if participants provide answers in a socially desirable way. Even though at the beginning of every interview the participants were noted that every interview was going to be analyzed anonymously and every participant had to talk about their own experiences. There are several signals that may indicate bias in the research. The first signal was that the tactic 'subjective' was not mentioned at all. This could mean that the respondents answered the questions in a socially desirable response. Respondents could also feel pressure not to speak freely. This might be because they have critical notes on their employer or their own job performance. Another reason why this was the case might be when things are sensitive in society. This happened during the interviews, when the participants asked to leave out certain aspects that they considered sensitive and did not want them to be made public and used in the thesis. It is also possible that the interviewees do not share their own opinions but feel obligated to represent the municipality's standpoint or way of working. What respondents say happens might not be in accordance with what happens. Bias might also occur in data analysis methods, as qualitative research is highly dependent on the researcher's interpretation of the spoken words. Possibilities reduce the bias in future research lie within interviewing more people or interviewing more people from the same municipality to better validate the findings.

Another limitation is that the sample size for qualitative research was only thirteen. Although, saturation was reached as not many new insights were generated over the final three interviews, the sample remains relatively small. Because of the relatively small sample, some tactics have not been named very often, therefore the conclusions should be interpreted with care. The question arises that if the tactics are not named often because they are not used, or if they are not named often because of the small sample size. Therefore, it might be interesting to redo the research with a bigger sample size and with that see if the same processes are observed. This could either be by interviewing more participants or by doing survey research among municipal decision-makers. Also, it might be interesting to research more into why some tactics, such as subjective tactics, are not mentioned or mentioned only once or twice in interviews. Furthermore, interesting to investigate further is the way the decision-making process works for highly innovative projects. This might be interesting, because several Nutt (2008) tactics were only mentioned in a highly innovative project. The decision-making process of the highly innovative project differed a lot from the Nutt (2008) framework and the other participants.

Working with a predefined research framework allowed systematic identification. A limitation is that a predefined research framework may result in boundaries in the interpretation of the data. It is important to consider that the decision-making process of climate change adaptation decisions may not fit within the designed research framework at all. Because it is how you interpret the data, basing it on the process that is found (M. Harrison & Phillips, 1991; Nutt, 2011). Nutt (2008) framework provides a helpful starting point, but the findings suggest that local government decision-making is deeply shaped by contextual and structural limitations. Further research might want to try and match data to another decision-making process framework, to see if that generates additional insights (for example the multiple streams framework as proposed by Goyal et al. (2020) and Kingdon (1984)).

Another limitation is that the context differs a lot between municipalities. Some municipalities were big, some were small, some projects started from an area development, others started from a coupling to projects, some have experience with extreme rainfall, some have not experienced this. Based on this several suggestions are made for future research. First it might be better to interview municipalities only about projects that started for the same reason. For example, redeveloping an area, or a project in the already existing public space. Second, consistency between the participants being employed at big, medium sized or small municipalities would be helpful. Then future research might look into how capacity, size, political pressure and available means influence the decision-making process and tactics. Third, the locations of the municipalities, should be consistent within the Netherlands, so that they are dealing with the same climate change related issues. Fourth, the effect of the location of the project is, being the old city center, a Vinex area or another neighborhood type could be researched. Fifth, the participants that were interviewed focused mainly on successful projects. This leads to the projects that have been canceled before execution not being discussed. This might lead to a wrong image of the actual decision-making process. Interesting is also, to research projects that have not been implemented and stopped before the execution could take place. Finally, doing the same research in different countries might also lead to different decision-making tactics. This would make clear whether these tactics are typically Dutch or also happen in an international context.

A final limitation is that the outcomes of the analysis are shaped by the interpretation of the researcher. If another person had conducted the same analysis, they might have assigned quotes to different phases or tactics. This subjectivity is inherent in qualitative research. To improve consistency and strengthen the validity of the findings, future research could benefit from collaboration with multiple researchers. By independently analyzing the same data and comparing results, they could identify discrepancies and work toward a more robust and validated interpretation.

7

Conclusion

The conclusion chapter is divided into the following paragraphs. Paragraph 7.1 provides an answer to the main research question. Paragraph 7.2 shows what the contribution to the academic literature is of the research. Finally, in Paragraph 7.3 recommendations for improving the decision-making process for climate change adaptation in practice are provided.

7.1. Answer to the research question

The aim of the research was to understand how Dutch municipalities make decisions about climate change adaptation measures for extreme precipitation events and to understand which context factors are perceived to influence that process. The main question that was answered in the research was:

"How do municipal level decision-makers perceive the decision-making processes around municipal climate change adaptation for extreme precipitation events and the factors that influence them?"

In conclusion, this research shows that the decision-making process for climate adaptation to extreme rainfall in Dutch municipalities is influenced by many different factors. Although similar patterns can be found in the decision-making processes of municipalities.

The decision-making process typically starts with an opportunity, such as obligations from the national government, area development or an infrastructure replacement. Alongside opportunities, needs emerge after an extreme weather event or when there is a water management challenge in a certain area. Needs provide urgency to take big action, while opportunities tend to be more slow waiting for coupling to other projects. From there, goals are set. These goals differ in their specificity. Objectives vary from taking concrete measures, such as retaining 50 mm of rainfall to more abstract goals such as 'becoming as climate adaptive as possible.' Sometimes an analysis is done to understand the problem, after which objectives are defined. Another possibility is that the climate change adaptation goals are integrated with the goals of the other domains. Solutions are then explored, through standardization, technical analysis, examples from other cities, or consultancy supports. Often standardization and looking at neighboring municipalities occur in small municipalities, mainly due to capacity limitations. While large municipalities use technical analysis to see if all goals are reached. Bargaining also emerges when within the available space other municipal goals need to be considered. By bargaining the project team or municipal departments negotiates which measures should be taken. Sometimes bargaining and analysis happen alongside each other. Solutions are evaluated based on the previously defined goals, budget, and stakeholder input, and finally implemented, usually through political decisions or interdepartmental negotiations.

However, the process is influenced by many contextual factors and perceptions. Practical challenges often arise due to limited space, unsuitable surroundings, or vulnerable environments. These challenges can sometimes be addressed with innovative solutions. However, such innovations often require more maintenance and involve higher costs than initially anticipated, while municipal budgets remain limited. Decisions about whether to pursue innovative ideas and how to allocate funding are made by the munici-

pality. In this, the administrative structure, local politics, and existing policies play a significant role. The choice to implement climate change adaptation measures is often a political one. When politicians feel a sense of urgency, more adaptation measures are implemented. Otherwise, other priorities for public space tend to take precedence. Political decisions are frequently influenced by measures that increase re-election chances. In such cases, climate change adaptation is often the first area to face budget cuts. However, when both politicians and residents have experienced extreme rainfall events, awareness of the risks increases, and more climate measures are implemented. Framing climate change adaptation as something that adds value to the neighborhood, for example adding green space, leads to broader implementation compared to a purely technical, risk-reduction perspective. Finally, responsibilities remain unclear. While residents are responsible for private space, they often expect the municipality to take the lead. Meaningful participation is essential to create a shared sense of urgency; otherwise, residents will continue to prioritize visible and immediate needs, such as parking.

In conclusion, climate adaptation decisions are not just technical. They are political, practical, and shaped by perception. Understanding and addressing these influences is key to building more climate-resilient cities and helping to achieve Sustainable Development Goal 11, aiming to make cities and human settlements inclusive, safe, resilient, and sustainable (Independent Group of Scientists, 2023).

7.2. Contributions to literature

The conclusions offer several important contributions to the scientific understanding of municipal decision-making for climate adaptation. This thesis contributes to literature in several ways.

First, the conclusions provide a contribution to understand the “implementation gap.” Although knowledge and possible measures on climate adaptation are widely available, actual implementation is often hindered by a lack of urgency, competing priorities, budget constraints, and spatial limitations. Notably, these barriers tend to vanish when extreme precipitation causes damage. The perception of risk is a big influence on the measures that are implemented. In these cases, political attention intensifies, and the urgency of climate adaptation becomes immediately clear. To bridge the implementation gap, political commitment must be increased, responsibilities should be clearly defined, residents should be involved, and long-term funding and maintenance planning should be secured.

In addition, this research offers valuable reflections on the applicability of the Nutt (2008) framework in public sector decision-making for climate change adaptation. The research shows that the framework is applicable in a new context. The phases of the framework generally align with the decision-making processes of individual actors. However, multiple tactics often coexist within the same phase. For example, Needs and Opportunities are identified simultaneously, and Solicitation frequently occurs alongside Innovation and Benchmarking. Similarly, problem analysis often precedes the formulation of Objectives. These findings suggest that Nutt’s tactics are not mutually exclusive. Instead, they are used in parallel, reflecting the complexity and adaptability of real-world decision-making.

Differences in large and small/medium sized municipalities are also important findings and contribute to literature. Small municipalities consistently adopt tactics based on standardization. For example, they adopt the idea and benchmark tactic. Suggested is that the reason for this is because of capacity limitations. In contrast large municipalities tend to adopt specific quantifiable goals based on an analysis of the problem. When evaluating the decisions, the goals are revisions to check if they are reached. Small and medium sized municipalities benefit from more data driven and innovative culture, while large ones need better coordination and process integration. Both contexts require different governance support structures.

7.3. Recommendations for practice

For policymakers working on climate change adaptation, this research shows that creating a sense of urgency and raising awareness of climate risks among residents, colleagues, and local politicians is important to create action. Clear reasons for taking measures must be established, as waiting for extreme weather events or project coupling often proves too late. Without urgency, local politics tend to favor projects with immediate, visible benefits, like parking or mobility. The first way to convince municipal politics of the importance of adaptation is to frame it to add value to neighborhoods. Linking climate change adaptation to ‘improving the living environment’ helps to build both internal and external

support. Because adaptation is often seen as a vague concept, many people struggle to understand its relevance. By presenting it as something that improves daily life, such as creating greener, more attractive public spaces, it becomes more relatable and easier to find support. The results show that this positive framing generates more public and political backing than when it is presented purely as a technical or risk-based necessity. Furthermore, to increase action, climate change adaptation should adopted by local politics. In this way climate change adaptation becomes an explicit part of municipal policy. Clear norms, goals and obligations embedded in municipal plans help to adopt climate change structurally. Alongside this, political actors should be involved early, especially when the project involves trade-offs like green space versus parking. This is important to avoid last-minute political overrides of climate change adaptation plans. Also to create more climate change adaptation action, the capacity of the project execution of the municipality should be increased. Enough budgets should be made available for climate change adaptation and skilled personnel that see climate change adaptation as a priority should be hired. This is necessary to ensure that municipal knowledge is not decreasing. These employees should have clear responsibilities and roles. Finally, campaigns must be started improving residential awareness and private responsibility regarding climate risk.

Besides creating urgency, the decision-making process of the municipality should be improved. The first recommendation is to make decision-making phases explicit. Projects should be structured in recognizable phases (Possibly based on Nutt (2008)), to ensure that decisions are transparent and traceable. This is recommended because the interviews showed that many decisions are politically overridden; making the process transparent helps to manage this. Furthermore, increasing the legitimacy of climate adaptation helps to limit the political overrides. Basing evaluations for climate change adaptation on data and models helps to strengthen the position of climate change adaptation. Every municipality should use the Objectives and Analysis tactic. Also, citizen participation should be a standard element of the decision-making process, with a clearly defined purpose. It is crucial to communicate clearly why the municipality intends to take specific actions, because if the reason why climate change adaptation is important remains unknown, the residents might advocate for other use of public space, such as parking. Municipalities should ensure that the challenges are explicitly presented to residents, and that the considerations and trade-offs are transparent. Without this clarity, participation may result in a de-prioritization of climate change adaptation ambitions. Next, process bargaining should be improved between policy, implementation, and politics. This should be done by organizing structured dialogues between policymakers, technical staff, and political actors to weigh feasibility, costs, and trade-offs. Integrated ambitions often clash in later phases due to conflicting goals. Therefore, the trade-offs should be made earlier in the process. Stimulating cooperation is also important. This cooperation should be happening between the departments of the municipality, between the municipality and the waterboards and with other relevant actors. This might be via integral project teams or collaborative decision-making. Finally, process ownership should be assigned per phase. The person responsible for the process should be appointed in each project phase. This person keeps the overview and knows what is happening where. This prevents fragmentation of responsibility, especially in complex, interdisciplinary projects.

A final recommendation is to improve knowledge sharing between municipalities, ensuring that each is aligned and aware of existing possibilities. It should not be necessary to reinvent the wheel in every municipality. Organizing conferences, sharing lessons learned, and create a strong, innovative culture both within and across municipal boundaries is essential. This can be supported by systematically documenting decisions and what outcomes they produce. Such procedural knowledge helps mitigate knowledge loss and enables learning across departments and future projects.

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A

Literature search

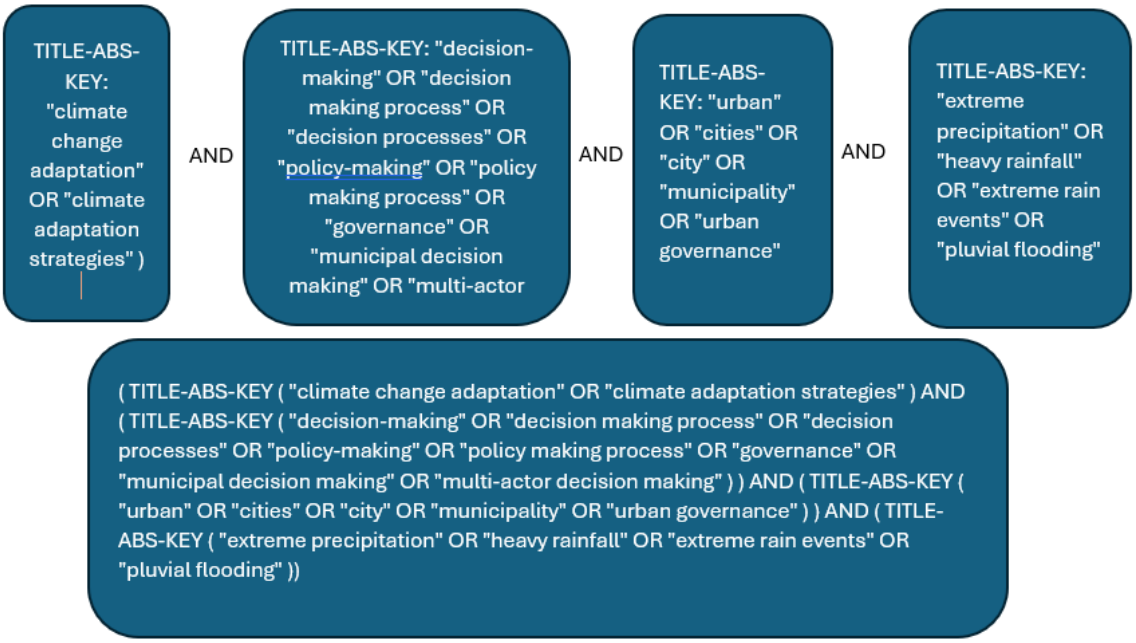


Figure A.1: Search string literature review

Figure A.1 provides an overview of the search string. The relevant parts of the search string were: 'climate change adaptation', 'decision-making', 'government', 'precipitation', and 'urban'. These keywords or synonyms of them needed to be mentioned in the title, abstract, or keywords of the paper. The search engine that was used to conduct the search is Scopus. Scopus is the largest database of scientific literature that is also peer-reviewed. Scopus also has many articles on applied public policy. Furthermore, to obtain results of the highest quality, only English and fully published articles were included in the search.

On the 26th of January 2025 the search was carried out, using the string as visualized in Figure A.1. In this search round, 17 documents were found with dates ranging from 2008 to 2025. Only peer-reviewed articles were selected, leaving 14 articles. Articles of Wang et al. (2023) and Sandholz et al. (2018), were not deemed relevant to the subject and outside of the scope. Wang et al. (2023) focused on adapting railways to climate change and Sandholz et al. (2018) focused on using eco-system based measures as adaptation to climate change. Therefore, Wang et al. (2023) and Sandholz et al. (2018) were both excluded from the search, leaving N = 12. These 12 articles are:

- Reinwald et al. (2024),
- Schoenefeld et al. (2023),
- Kvitsjøen et al. (2021),
- Madsen et al. (2019),
- Trell and van Geet (2019),
- Halsnæs and Kaspersen (2018),
- Arnbjerg-Nielsen et al. (2015),
- Roders and Straub (2015),
- Q. Zhou et al. (2012),
- Fatti and Vogel (2011),
- Amundsen et al. (2010) and
- Roberts (2008).

A.1. Relevant literature provided by supervisors & snowballing

More articles were added to the literature review via forward snowballing and recommendations by the research team. These articles are not all scoped to extreme precipitation events, but more general to climate change adaptation and are still relevant for the thesis topic. The research team suggested the following articles:

- Siders and Pierce (2021),
- Biesbroek et al. (2015),
- Preston et al. (2015),
- Braams (2023),
- Owen (2020),
- Nutt (2008),
- Oulahen et al. (2018),
- Dilling et al. (2017),
- Simonet and Leseur (2019),
- Wolf et al. (2021),
- Temby et al. (2016) and
- Azhoni et al. (2017).

which were added to the literature review, leaving N = 20. After which, using forward snowballing, all the other articles were added.

B

Interview guide

B.1. Interview guide Nederlands

De vragen met de buitenste bullet points zijn de hoofdvragen die ik sowieso zal stellen. Als het antwoord niet voldoende detail biedt, zal ik de onderliggende bullet points gebruiken om verder door te vragen en zo een volledig beeld te krijgen.

Bedankt voor uw deelname aan dit interview. Dit onderzoek richt zich op hoe beslissingen over maatregelen over klimaatadaptatie voor extreme regenval worden genomen. Ik zal u vragen om een project in gedachte te nemen dat al geïmplementeerd is en dat gerelateerd is aan extreme regenval.

Het doel is om het besluitvormingsproces te begrijpen en welke stappen erin worden genomen binnen uw gemeente. Ik ben ook geïnteresseerd in welke strategieën er gebruikt worden en hoe de bredere context en uw persoonlijke perceptie een rol spelen in het proces.
Er zijn geen goede of foute antwoorden; ik ben geïnteresseerd in uw persoonlijke ervaring. Alle antwoorden zullen mee worden omgegaan als beschreven in de informed consent form en zullen anoniem worden verwerkt.

Heeft u vragen hierover?

Zo niet: Schroom svp niet om tijdens het interview te onderbreken en vragen te stellen mocht er iets niet duidelijk zijn of u zich oncomfortabel voelen.

Introductie:

- Kunt u iets vertellen over uw rol binnen de gemeente?
  - Hoe sluit dit aan op besluitvorming over maatregelen voor klimaatadaptatie?

Algemene vragen:

- Kunt u een klimaatadaptatieproject beschrijven dat u recent heeft uitgevoerd of dat binnenkort wordt uitgevoerd?
- Hoe gaat op grote lijnen dit beslissingsproces van opstart tot implementatie?
  - Wat waren de mijlpalen door de tijd heen?

Decision-making process:
1. Intelligence gathering:

- Waarom bent u met dit project gestart?
  - Hoe werden de behoeften aan verandering of verbetering vastgesteld?
- Waarom kreeg dit project prioriteit?

Percepties:

- Wat denkt u dat de reden is dat de opstartfase zo verliep?
  - Was de opstartfase succesvol?
- Hoe ervoer u zelf de urgentie van het probleem?
  - Was dat anders dan hoe anderen dit zagen?
- Wat is uw perceptie op hoe de initiatie fase verliep?

2. Directions from
   - Op welke manier werd bepaald welk beleid of welke maatregelen nodig waren in dit project?
   - Welke overwegingen speelden een rol?
     - Werd een bestaand idee of een eerder succesvol project als richtlijn gebruikt?
     - Werd er een analyse uitgevoerd om het probleem beter te begrijpen?
     - Waren er vooraf vastgestelde doelen of gewenste uitkomsten die de richting bepaalden?
     - Of andere overwegingen of invloeden?

Percepties:

- Denkt u dat dit een goede methode is om te bepalen welke maatregelen nodig zijn?
- Hoeveel flexibiliteit was er in uw besluitvorming?
- Wat is uw perceptie op dit beleid?

3. Solutions found by:
   - Hoe werden mogelijke adaptatieoplossingen gevonden?
     - Was de oplossing standaard of innovatief?
     - Werd de oplossing al toegepast in andere steden of gebieden, en was deze daarop gebaseerd?
     - Was de oplossing speciaal voor deze situatie ontwikkeld?
   - Welke partijen buiten de gemeente waren betrokken bij het vinden van oplossingen

Percepties:

- Waarom heeft u voor deze manier van oplossingen vinden gekozen?
  - Waren er voorkeuren voor bepaalde typen oplossingen?
- Wat is uw perceptie van deze manier van oplossingen vinden?

4. Evaluation by:
   - Werden meerdere opties overwogen?
   - Hoe werden deze opties vergeleken?

Percepties

- Waarom werden de alternatieven op deze manier geëvalueerd?
- Wat vindt u van deze manier van evalueren?

5. Implementation
   - Hoe werd de uiteindelijke beslissing genomen?
   - Welke uitdagingen kwamen naar voren?
   - Hoe werd draagvlak gecreëerd
   - Hoe werd de beslissing uiteindelijk geïmplementeerd?

Percepties:

- Waarom verliep deze stap in het proces zo?

- Wat is uw perceptie op deze manier van beslissingen maken?
  - Hoe belangrijk was het voor u om publieke en stakeholdersteun te krijgen?
  - Hoe werd bepaald of er voldoende maatschappelijke steun was?
  - Hoe ervoer u weerstand of acceptatie van de beslissing?

Context

- Welke context factoren hadden de grootste rol in het gehele besluitvormingsproces en waarop had dit invloed?

Conclusie:

- Was dit een typisch voorbeeld van een besluitvormingsproces binnen uw gemeente of is dit een uniek proces?
  - Wat maakte het een uniek proces? Verwacht u dat in de toekomst ook voor elke maatregel een uniek proces moet worden opgetuigd?
  - Hoe zou het proces er op de grote lijnen anders hebben uitgezien als het een typisch geval was?
- Is er iets belangrijks dat ik nog niet heb genoemd of dat u zou willen toevoegen?
- Is er iemand anders die u aanbeveelt om te interviewen?

B.2. Interview guide english:

The questions with the outer bullet points are the main questions I will definitely ask. If the answer does not provide enough detail, I will use the underlying bullet points to follow up and get a complete picture.

Thank you for participating in this interview. This research focuses on how decisions regarding climate adaptation measures for extreme rainfall are made. I will ask you to think of a project that has already been implemented and is related to extreme rainfall.

The goal is to understand the decision-making process and the steps involved within your municipality. I am also interested in which strategies are used and how the broader context and your personal perception play a role in the process.
There are no right or wrong answers; I am interested in your personal experience. All responses will be handled as described in the informed consent form and will be processed anonymously.

Do you have any questions about this?

If not: Please do not hesitate to interrupt during the interview to ask questions if anything is unclear or if you feel uncomfortable.

Introduction:

- Can you tell me about your role within the municipality?
  - How does this relate to decision-making about climate adaptation measures?

General questions:

- Can you describe a climate adaptation project that you have recently carried out or that will soon be implemented?
- How does the decision-making process generally proceed from initiation to implementation?
  - What were the milestones over time?

Decision-making process:
1. Intelligence gathering:

- Why did you start this project?

  - How were the needs for change or improvement identified?
- Why was this project given priority?

Perceptions:

- What do you think was the reason the initiation phase went the way it did?
  - Was the initiation phase successful?
- How did you personally perceive the urgency of the problem?
  - Was this different from how others saw it?
- What is your perception of how the initiation phase went?

2. Directions from
   - In what way was it determined which policy or measures were needed in this project?
   - What considerations played a role?
     - Was an existing idea or a previously successful project used as a guideline?
     - Was an analysis carried out to better understand the problem?
     - Were there predetermined goals or desired outcomes that guided the direction?
     - Or were there other considerations or influences?

Perceptions:

- Do you think this is a good method to determine which measures are needed?
- How much flexibility was there in your decision-making?
- What is your perception of this policy?

3. Solutions found by:
   - How were possible adaptation solutions found?
     - Was the solution standard or innovative?
     - Was the solution already applied in other cities or areas and based on that?
     - Was the solution specifically developed for this situation?
   - Which parties outside the municipality were involved in finding solutions?

Perceptions:

- Why did you choose this way of finding solutions?
  - Were there preferences for certain types of solutions?
- What is your perception of this way of finding solutions?

4. Evaluation by:
   - Were multiple options considered?
   - How were these options compared?

Perceptions

- Why were the alternatives evaluated in this way?
- What do you think of this method of evaluation?

5. Implementation
   - How was the final decision made?
   - What challenges arose?
   - How was support created?

- How was the decision ultimately implemented?

Perceptions:

- Why did this step in the process proceed the way it did?
- What is your perception of this way of decision-making?
  - How important was it for you to gain public and stakeholder support?
  - How was it determined whether there was sufficient societal support?
  - How did you experience resistance or acceptance of the decision?

Context

- Which contextual factors played the largest role in the entire decision-making process, and what did they influence?

Conclusion:

- Was this a typical example of a decision-making process within your municipality, or was it a unique process?
  - What made it a unique process? Do you expect that in the future a unique process will have to be set up for every measure?
  - How would the process have looked different in broad terms if it had been a typical case?
- Is there anything important that I haven't mentioned or that you would like to add?
- Is there anyone else you recommend I interview?

C

Informed consent form

C.1. Dutch informed consent

Informed consent statement U wordt uitgenodigd om deel te nemen aan een onderzoek genaamd Analysis of the decision-making processes of local policy-makers on urban climate change adaptation for extreme precipitation. Dit onderzoek wordt uitgevoerd in het kader van de Masteropleiding van en door Suzanne Wink bij de Technische Universiteit Delft, in samenwerking met APPM Management Consultants.

Het doel van dit onderzoek is om te begrijpen hoe beslissingen over klimaat adaptatie worden genomen door gemeenten en zal ongeveer 60 minuten van uw tijd in beslag nemen. De data zal gebruikt worden voor het schrijven van de Master thesis en een mogelijke publicatie die daarbij hoort. U wordt gevraagd om interview vragen te beantwoorden die zullen helpen inzicht te verkrijgen in het beslissingsproces over klimaatadaptatie.

Het interview zal worden opgenomen en worden getranscribeerd. Zodra het transcript is gemaakt zal het naar u worden opgestuurd om te worden nagekeken. Mocht u aanpassingen willen maken zal het transcript worden aangepast zoals u dat zou willen. Zoals bij elke onlineactiviteit is het risico van een databreuk aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. De data zal geanonimiseerd worden opgeslagen en geaggregeerd worden in de resultaten en alleen geanonimiseerde quotes zullen mogen worden gebruikt in het onderzoek en de daaruit volgende master thesis en evtl. erop volgende publicatie.

We minimaliseren de risico's door alle data te anonimiseren en op te slaan op de servers van de TU Delft. De data is alleen toegankelijk voor het researchteam van de TU Delft. De geanonimiseerde data zal tot 10 jaar na het afnemen van het interview worden opgeslagen en zal mogelijk worden hergebruikt voor wetenschappelijke en onderwijsdoeleinden met als onderwerp klimaatadaptatie door publieke sectoren. De masterthesis zal uiteindelijk worden gepubliceerd in de TU Delft thesis repository (https://repository.tudelft.nl/). De transcripties van de interviews zullen als bijlage bij de thesis worden gevoegd en quotes uit de interviews zullen worden gebruikt in de master thesis.

Uw deelname aan dit onderzoek is volledig vrijwillig, en u kunt zich elk moment terugtrekken zonder reden op te geven. U bent vrij om vragen niet te beantwoorden.

Contactpersoon en onderzoeker: Suzanne Wink,

Begeleider vanuit TU Delft: Lisa Scholten

Ik heb de bovenstaande informatie gelezen en begrepen en ik ga akkoord met mijn deelname aan het interview en ik ga akkoord met het gebruik van de data zoals beschreven.

Datum:

Handtekening:

C.2. English informed consent

You are invited to participate in a research project called Analysis of the decision-making processes of local policy-makers on urban climate change adaptation for extreme precipitation. This research is being conducted as part of the Master's program of and by Suzanne Wink at Delft University of Technology, in collaboration with APPM Management Consultants.

The purpose of this research is to understand how climate adaptation decisions are made by municipalities and will take about 60 minutes of your time. The data will be used to write the Master thesis and a possible publication that will accompany it. You will be asked to answer interview questions that will help gain insight into the climate adaptation decision-making process.

The interview will be recorded and transcribed. Once the transcript is created it will be sent to you for review. Should you wish to make adjustments the transcript will be edited as you would like. As with any online activity, there is a risk of a data breach. We will do our best to keep your responses confidential. The data will be stored and aggregated anonymously in the results and only anonymized quotes will be allowed to be used in the research and the resulting master thesis and possibly subsequent publication.

We minimize risk by anonymizing all data and storing it on TU Delft servers. The data can only be accessed by the research team at TU Delft. The anonymized data will be stored up to 10 years after the interview was conducted and will possibly be reused for scientific and educational purposes on the topic of climate adaptation by public sectors. The master thesis will eventually be published in the TU Delft thesis repository (https://repository.tudelft.nl/). Transcripts of the interviews will be appended to the thesis and quotes from the interviews will be used in the master thesis.

Your participation in this study is completely voluntary, and you may withdraw at any time without giving a reason. You are free not to answer questions.

Contact person and researcher: Suzanne Wink,

Supervisor from TU Delft: Lisa Scholten,

I have read and understood the above information and I agree to participate in the interview and I agree to the use of the data as described.

Date:

Signature:

D

Process maps

In this appendix all the process maps that are designed based on the interviews, will be discussed. These process maps are used as a basis for the analysis and results chapter of the thesis. With the arrows representing the relations that are shown as perceived by the interview participant. The process steps and the influences perceived by the participant are shown in the white squares. The processes are shown in green

D.1. Participant 1

The process map for Participant 1 is visualized in Figure D.1. The first participant was an Urban Designer who did multiple projects in different municipalities. As an urban designer she did the design of urban area development. Governments and project developers ask her to create the design for area re-development. She liked the job she was doing because she *"Genuinely thinks it can add value"*, not specifically the technical measures, but the measures that help to create a nice environment. She is enthusiastic and therefore she can take people along with her in enthusiasm. She believes that the person that is doing the job can have a real impact.

The project she described during the interview was a big area re-development in a big city in the Netherlands, in a very paved neighborhood that faced a water management challenge. The area was in property of the municipality before. In this project a tender was issued. In this tender there were high quality objectives for climate change adaptation, which was decided by the municipality who took responsibility to fix the problems. The urban designer went further than the quality restrictions in their climate change adaptation and they won the tender. "*a tender was issued by the municipality, so the land belonged to the municipality. They issued a tender and set some minimum requirements for climate adaptation. In the tender consortium, we actually went much further than the requirements they initially set."* Often there is a debate between public and private actors that disagree on who is responsible. Participant 1 described this as: *"By solving this part, you could also address a larger portion of the problem. With climate adaptation, it's always like this… Sure, it happens to fall on your roof, but if you don't green your roof, the water might end up in your neighbor's basement, for example. So, I see climate adaptation as… well, I always call it a collective good; it belongs to no one, and no one is responsible for it. That's why you often hear people say, "Why should I green my roof?" Because you're not the only one who benefits from it. You are the only one who bears the cost, but the benefits are shared by many. So the benefits are often spread across different parties or individuals, which makes climate adaptation interesting, but also more complex when it comes to figuring out who should take responsibility."* In this political attention also plays a role.

So, when the tender was issued multiple real estate developers applied for the project and had to send in their plans, which was analyzed based on the objectives that were set beforehand. It is important that the municipalities set high objectives on the matter because the real estate developers are not going to do much on climate change adaptation on their own: *"Because the developer usually doesn't take much initiative on their own, I've noticed that too , they're not likely to do a lot voluntarily. It's often just*

quite expensive and complicated." This urban designer feels that it is very important to create value and couple climate change adaptation to creating a nice living environment: '*If you go out on the street and ask people, "What would you like to see changed in your street?", not a single resident will say, "I want a climate-adaptive street." But they will say things like, "I want a pleasant street where my children can play safely," or mention greenery. They do mention green spaces, or opportunities to meet others, but they don't name climate adaptation specifically. So, from a design perspective, we really focus on: How can you design in a way that creates extra space for social interaction? Especially in an urban area that is already highly paved and densely populated. So, we often link those elements together, climate adaptation combined with another theme, like social interaction or community-building. That way, you suddenly create space, and at the same time, you improve the quality of the living environment. Not just for things like flooding, but also for heat and drought. So I think that's always an important incentive to actually do something.*" Here the quality of the idea and the price of the land are two important factors on which every proposal is scored. Now the project has to be executed and faces appeals from neighbors, this takes a very long time.

The design of the Urban designer beheld that a second landscape is created on the roof. Here the water is collected and infiltrated. Their goal was to create value, because with just technical solutions they could also have met the requirements. The personal traits of the policy makers are also very important, as their enthusiasm in the end determines the goals that are being set.

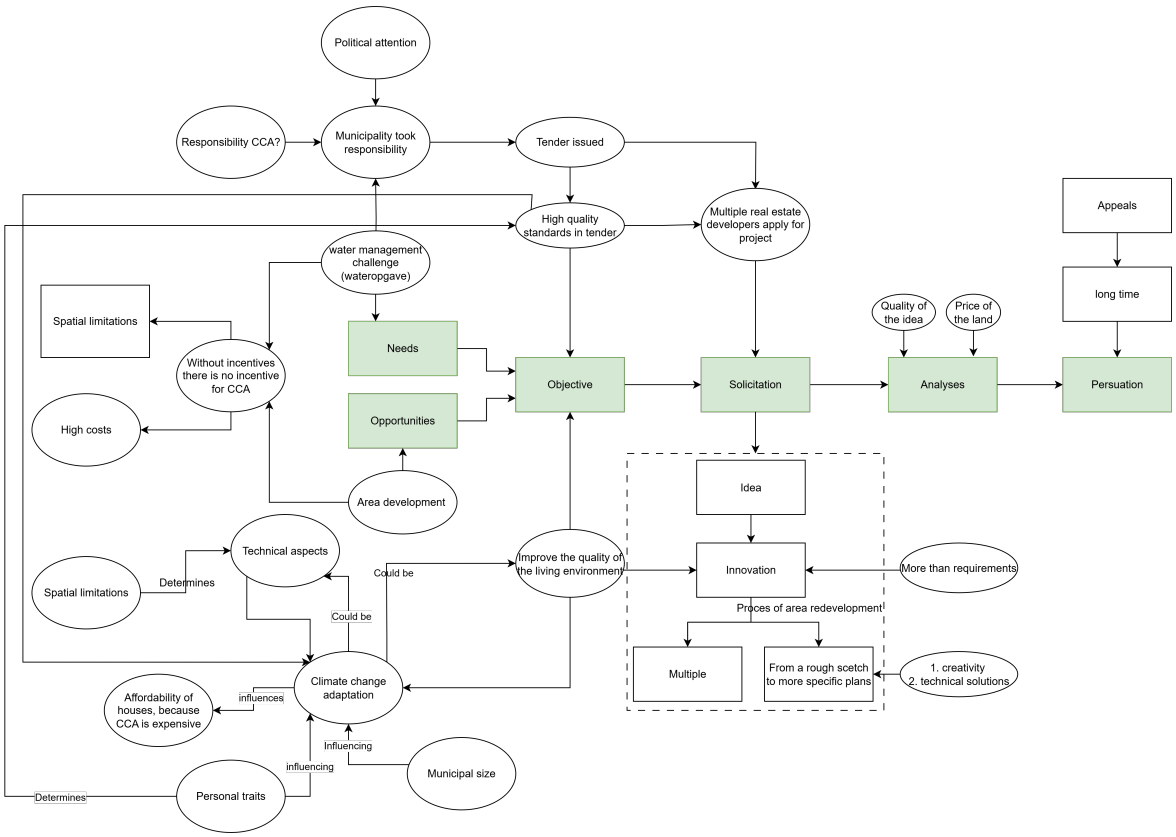


Figure D.1: Process map participant 1

D.2. Participant 2

Participant 2 was employed at different municipalities. The process maps of participant 2 are shown in Figure D.2. In these municipalities he was working as a policy officer. In the interview he talked about 2 projects, one in a large and one small municipality. The large size municipality is mentioned as participant 2A whereas the small size municipality was mentioned as participant 2B.

In general participant 2 had many comments on the way of working of big municipalities, small munici-

palities and the central government. The participant emphasized that the size of the municipality plays a crucial role in the effectiveness of climate adaptation. Large municipalities have more resources, but also more bureaucracy and less overview. Medium-sized municipalities are often the most effective: *"Big enough for specialization, small enough for overview and collaboration."* Small municipalities, on the other hand, depend on individuals with intrinsic motivation, which makes their influence relatively large but continuity vulnerable. The central governments also lack overview.

Furthermore, the role of organizational culture and motivation was strongly emphasized. A culture that allows room for experimentation and trust in employees leads to innovation. *"Money is not always decisive; time, capacity, and motivation are often more important."* Political orientation and leadership also influence the level of ambition and implementation.

A big difference they notice can be explained with the following quote: *"A city like X also has a drive for national and international profiling, especially in the field of climate adaptation. When you receive European subsidies, you have to showcase what you've done and present it. Interestingly, I also visit places in municipality X or municipality X, where an official shows me around and says: 'Look, this is what we've done.' And I think, yes, this is super climate adaptive. But there is no motivation or drive to promote it widely. First, it's much harder for them to take the stage because they are already very busy with many things. And second, there is no need for them to profile themselves."*. That is why the smaller municipalities get less attention from the central government and less is known about their performance and way of working.

D.2.1. Participant 2A

Participant 2A, a large municipality, adopts a unique process. This municipality is a front runner in the direction of climate change adaptation and that is what they want the outside world to see of them. The project described by this municipality is focused on testing a new and innovative idea.

They begin the project with a crazy idea, and then enthusiasm emerges. *"Look, where it all starts is with a brilliant and somewhat strange idea." "We believe it should be possible to create a park on X […] I think what they do in greenhouse horticulture, collecting, purifying, and storing water 20 meters underground, should also be possible on a city scale.* Then they need to create a comprehensive story on why this led to added value to the city. Budgets are available to analyze whether they could be feasible. *"Then you see that in a city like X, strategists, urban management, and urban development teams get involved. They pick up on this and think: 'There's something in this.' They then make budget available for design-based or exploratory research." "So there's no political decision-making involved at that point, it's just budgets that certain people have access to. Budgets of €30,000 to €40,000 for research."* After this research more enthusiasm emerges. Then they start looking for suitable locations where they could try and implement this innovation and test how it performs. This is based on an opportunity rather then a necessity. *"Then the next step is: can we find places where water supply and demand come together?"* and *"If two or three locations emerge with potential, and those conversations are ongoing, then you notice that a city like X says: 'Yes, we just need to do this."*. Then subsidies are gathered the politics are informed. Subsidies are interesting because with subsidies: *"You can tell your board: 'Look, other parties also find this very interesting and are contributing financially.' But that also creates some pressure in terms of timing and decision-making. Namely, if we don't do this now, the subsidy will no longer be available. And we've already applied for that subsidy."* and from there, the project moves directly into implementation, without much further analysis or iteration. No other participant described their project in this sequence. *"At that point, costs are no longer the determining factor." "Then city officials are informed, and to finance and explore it further, we link it with X and X to bring in additional funding." "That funding pressure means that decisions have to be made, because if we don't act now, we'll miss out on the subsidy. That subsidy has been applied for, and it's signed off politically or delegated to directors or managers. But without any deep technical analysis or needs assessments." "There's so much trust within the organization, and the culture in X supports this kind of experimentation and discovery."*

According to the participant, the reason why this project can happen in this way is because of the culture. There is much trust between the employees of the municipality. Embedded in the culture as well is the need for experimenting.

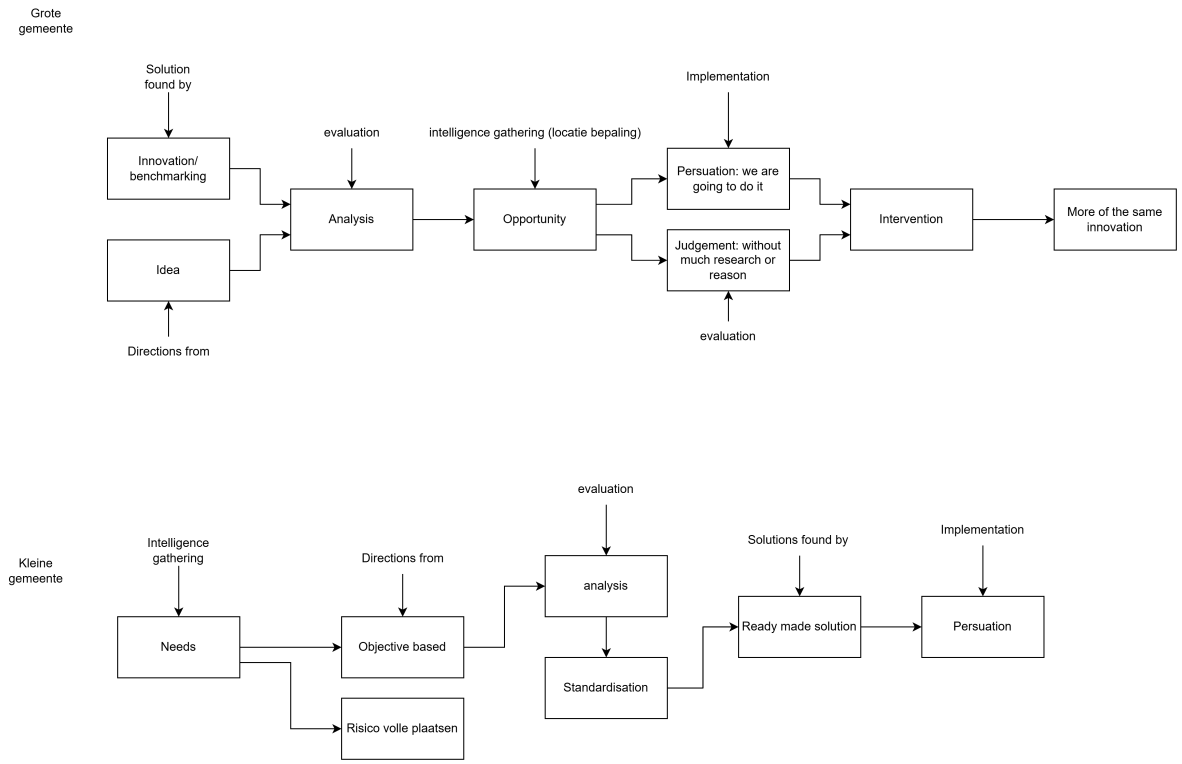


Figure D.2: Process map participant 2

D.2.2. Participant 2B

The second project took place in a small municipality where climate adaptation has been structurally embedded into policy and practice. In this municipality, every road reconstruction project includes the implementation of a water-retaining road surface, and every adjacent grass field is systematically transformed into a wadi. As participant 2 explained: *"With every road reconstruction, we standardly lay down a road that has water retention, and for every large grass field along it, we standardly make wadis."*

This approach is not incidental but structurally embedded in municipal policy. The municipality has incorporated the associated costs into the sewage levies paid annually by residents: *"They have fully settled that in the sewage levy, and they really make every project climate-proof that they do."*

The climate adaptation advisor in this municipality is highly experienced and politically savvy. He knows how to formulate ambitious goals and navigate the political landscape effectively: *"This man [...] had already worked in various municipalities and brought this experience and expertise with him."*

His strategic approach includes deliberately asking for more than needed, knowing that only part of the request will be granted: *"Then I also know that I have to ask for double."*

In this small municipality, the city council is also closely involved. The advisor mentioned having had multiple sessions with both the college and the council: *"For the strategy, I sat three times with the college and had one session with the Council."*

This political support, combined with a motivated internal culture, has enabled the municipality to become a front runner in climate adaptation: *"We don't have many problems now, but that's because we started this already 10 years ago."*

Rather than focusing only on high-risk areas, the municipality applies a consistent standard across all projects, while reserving additional budgets for the most vulnerable locations: *"They analyzed 20 spots where there is an increased risk. And they have set aside a separate budget for that."*

D.3. Participant 3

Participant 3 is an advisor for flood management in their municipality, and he thinks about policy and strategy. The process map is visualized in Figure D.3. He emphasizes that water nuisance is a multi-faceted issue that requires more than just engineering solutions: *"You cannot prevent urban flooding with technical measures alone."* They describe water nuisance and their solutions being: *You can enlarge sewer pipes, create storage facilities, or capture water. But you can also do something more on the side of impact mitigation. So also... yes, we've done a lot of research into whether you can warn residents, what measures residents can take, what we can do ourselves during such a heavy downpour. So, it has both sides, and I'm involved in both."*

What they standard do is replace the sewing system once they are at their eol. They wrote three plans to be able to do more: 1. only improve sewage capacity, 2. include green into municipal sewer taxes, option 3 also includes roads. Political decision was for now to only do option one in light of climate change adaptation. The reason was that the municipality faces budget cuts and municipal elections are due next year.

When these projects are due, they have to collaborate with the other departments to come up with integral goals for the projects. They have standardized that they always increase the sewing system with one benchmark rainfall from the Rioned catalogs. The project discussed was a sewer replacement and rainwater disconnection initiative. In this project, rainwater was disconnected from the combined sewer system and redirected to surface water. *"Whenever we replace sewers, we always disconnect the rainwater, so it no longer goes to the treatment plant."* This approach is part of a broader strategy to integrate climate adaptation into routine infrastructure work; this emphasizes an integral way of working: *"You combine tasks, make use of the opportunity when the street is already open."*

However, the participant is realistic about the limitations of such measures. Underground water storage, for example, is often ineffective during extreme rainfall events: *"A water storage facility won't do much. We're talking about 60 to 100 mm per hour, and those systems can't handle that."* Instead, the municipality focuses on managing water on the surface and preventing it from entering homes: *"It's about accepting that water will be on the streets more often, but making sure it doesn't enter houses."* In general, the participant raises questions about whether it is possible to solve the problems of extreme rainfall. Green spaces and technical measures do not do much according to him. It is better to create awareness for residents that these problems are happening and increasing. There is limited perspective on solutions to solve the problems: *"so you can actually do little to really reduce the effects of water nuisance"*. Not only are the possibilities limited but the possibilities that do have an effect cost way too much. So, what they have researched if they can alarm the residents ahead of a flooding so that they can place flood barriers. But the problem with this is that the precipitation is very local, and if they warn and nothing happens their reliability also reduces.

The municipality uses an integrated planning process, starting with the municipal sewer plan and a programming table where projects are prioritized based on effectiveness and feasibility: *"We look at the entire water system, sewers, surface water, and terrain, and assess which measures are effective."* Despite this structured approach, budget constraints often limit what can be implemented: *"If there's no money, ambitions are either dropped or scaled back. But the project itself still goes ahead."* Also, the type of soil is a big determinant in what is possible and it is important that the measures could be maintained.

Besides the municipal responsibilities, the participant also highlights the importance of public awareness and private responsibility: *"We do our best to reduce flooding, but we can't solve it completely. Residents also have a role to play."*

D.4. Participant 4

Participant 4 is a policy advisor for water and climate adaptation at a Dutch municipality. He is responsible for developing and steering policy and advising the municipal executive. An overview of the interview is provided in D.4. His involvement in climate adaptation began after an extreme rainfall event in 2014, which became a turning point for the city's climate policy: *"We had 80 to 130 mm of rain in two hours [...] the heaviest rainfall ever recorded in the Netherlands. That's when we said: we need to learn from this."*

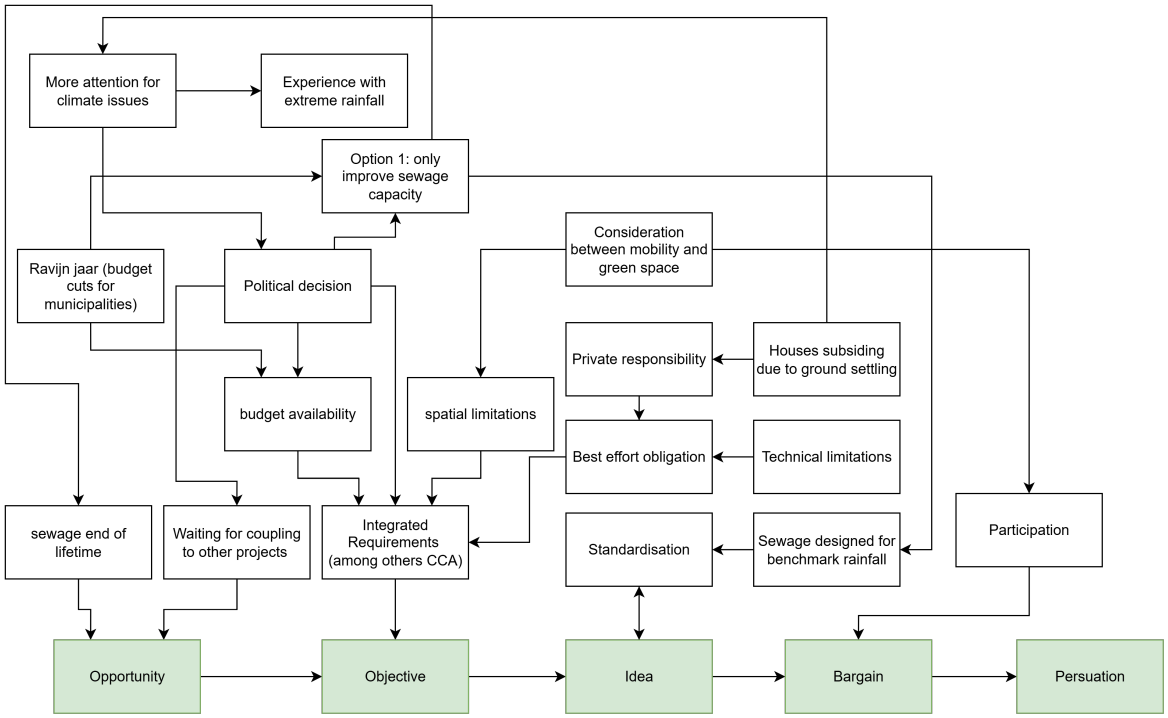


Figure D.3: Process map participant 3

The project they described involved in the beginning the transforming an unused bus lane into a green wadi. This was a very hot place, where water management challenges emerged. These water management challenges lead to problems in a downstream neighborhood. Later on, the mobility department got involved, which let to way more budget, as then the project involved transforming a concrete access road into a green corridor with wadi systems and trees. The project took 6–7 years to prepare and required political support due to its impact on traffic and parking: *"It's a prestige project [...] you're redesigning one of the city's main access roads.*" When it became a big project, they could use more subsidies.

The decision-making process was politically sensitive and involved multiple departments: *"You need to frame the project positively to get a decision. If you approach it negatively, it won't happen."* With these multiple department negotiations took place, because there was limited available space. The objective of the project was to make green what could be made green.

Public participation is central to this approach:*"We created a platform initiated by residents [...] they are our communication channel to the public."* In this it is important that residents take their own responsibility. The municipality tries to support this by providing subsidies for climate change adaptatoin measures.

Framing projects in terms of livability rather than climate adaptation helps gain support: *"If residents want a barbecue area, they get one. I call it climate adaptive at the office."* The municipality integrates climate adaptation with improving public space and quality of life. This created more support in local politics. Compared to technical ways of looking at climate change adaptation, using green spaces is a way to add to the value. People understand in this way more why the measures are needed.

The city uses various funding sources, including a €12 million climate adaptation fund. This enables projects that go beyond basic infrastructure: *"You can do useful things, but also things that look good, and that's important too."* Participant 4 emphasizes the importance of intrinsic motivation and a broader, integrated perspective, to actually make a change in climate change adaptation. He sees his role as connecting disciplines and interests: *"My project is part of a bigger environment. I need to look beyond just my task."* but this requires changes in the current way of working. *"It requires a different way of*

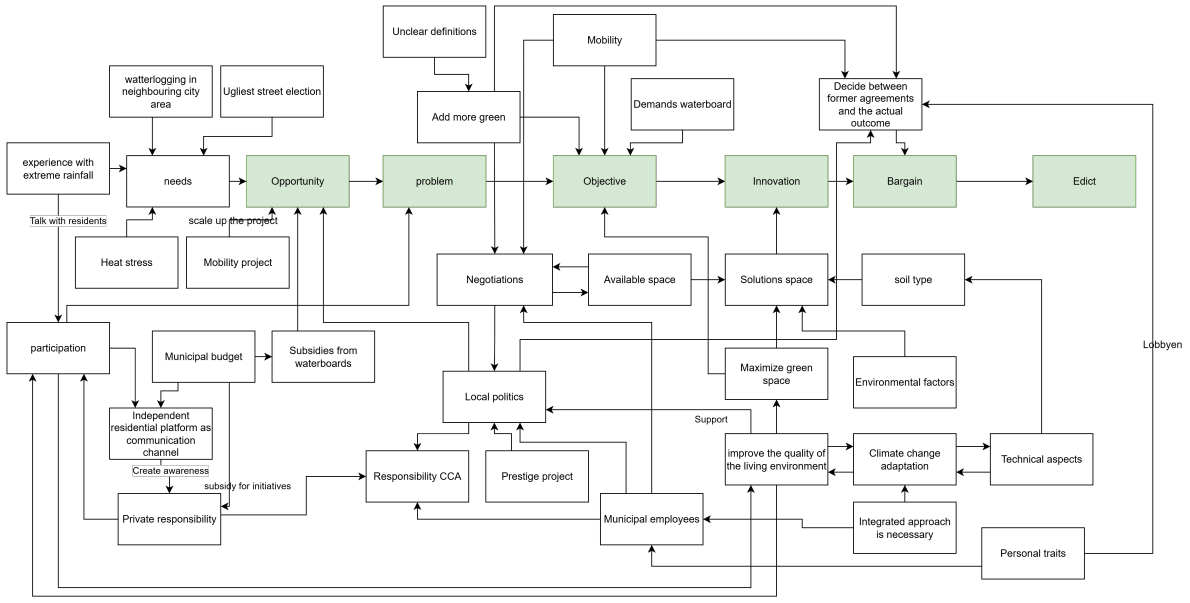


Figure D.4: Process map participant 4

thinking from politicians, policymakers, and maintenance staff."

For every project new challenges emerge, so creativity and tailoring the project to a specific situation is required. Lack of space, especially in older neighborhoods, is a major challenge. Collaboration with other departments and the water board is essential but sometimes difficult.

D.5. Participant 5

The process map of Participant 5 is visualized in Figure D.5. Participant 5 is a policy advisor for water and climate adaptation at a Dutch municipality. His role focuses on the strategic and tactical integration of water-related goals into urban development and infrastructure projects. He is involved in determining which climate adaptation measures should be included in projects, particularly those related to extreme rainfall.

The project discussed involved the redevelopment of a street where sewer replacement, storm water drainage, and climate-adaptive design were integrated. The municipality has developed a water vision map in how they want the sewing system to look like in the future. Every time a project is started these maps and stress tests are looked at and based on them is decided what the requirements are for the project.

The project was prioritized because the street served as a key drainage route for surrounding neighborhoods: *"This was an important artery in the system. That's why it was important for us."* The decision-making process involved analyzing stress test maps, groundwater data, and the municipality's water vision map to determine the need for intervention: *"We look at where the bottlenecks are, what the boundaries are, and what our contribution should be."*

The municipality uses a structured process to determine which measures are necessary. Each department contributes its own goals and funding, which are then weighed against spatial and financial constraints: *"Everyone brings in their own goals: trees, parking, heating networks, water storage, and then we see what fits."*

To avoid late-stage conflicts, the city is working on moving key decisions to the early planning phase: *"We're trying to bring those choices forward so we can make integrated decisions earlier."* The reason for this is that currently in the beginning they can already feel that all objectives are not going to fit into the available public space. Therefore, it is better to move the integral decisions to the front of the project, to provide clarity at the beginning

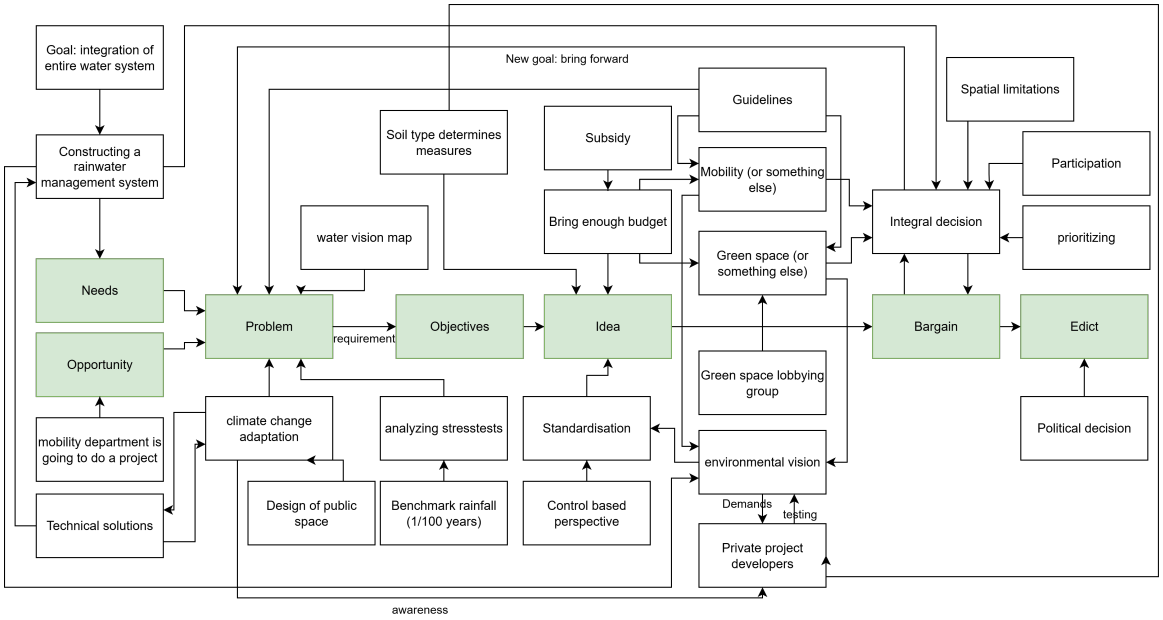


Figure D.5: Process map participant 5

Projects are often phased due to financial limitations. In this case, the project was split into two phases, with the second phase implemented after securing additional subsidies: *"We couldn't finance the full implementation at once, so we did it in two phases."* Each department contributes its own budget, such as the water department using funds from the water care levy (formerly the sewer levy).

In larger developments, such as around the central station, the city sets spatial and environmental frameworks (e.g., water storage, green space) that private developers must follow: *"They must submit an urban design plan that we assess against our frameworks."*

Developers are getting incentives to choose high-quality green solutions through flexible requirements:*"If you choose a green roof instead of a gravel roof, you need to provide less additional green space."*

The city ensures fairness by applying the same rules to all developers: *"Developers want a level playing field. If I have to do it, my competitor should too."* They check if the rules apply in the design of the project. If these objectives are not met, they need to come up with additional measures.

While water management is well-quantified, addressing heat and drought is more complex: *"Heat stress is harder to quantify. We try to address it through greening policies and tree planting."* The city has policies for cooling zones and green infrastructure, but acknowledges that these issues have only recently gained structured attention.

Participant 5 is driven by the long-term societal relevance of climate adaptation: *"You're not just building houses; you're building livable neighborhoods. The decisions we make now will affect the next 40 to 50 years."* With a background in environmental science and 17 years' employment at a water board, he brings an integrated perspective to municipal water policy.

D.6. Participant 6

The process map of Participant 6 is visualized in Figure D.6. The 6th participant works at a small municipality, which has not yet experienced extreme rainfall. The participant was the advisor of climate change adaptation here. The municipality was required by the Delta Program to carry out stress tests for climate adaptation. They did this by hiring an external consultant to perform the tests for them. The goal of the municipality is to be climate change adaptive by 2040. The guideline set by the national government is to be climate change adaptive by 2050.

In these stress tests, they looked at the "design storm" of 1/100 years and heat stress. This allowed

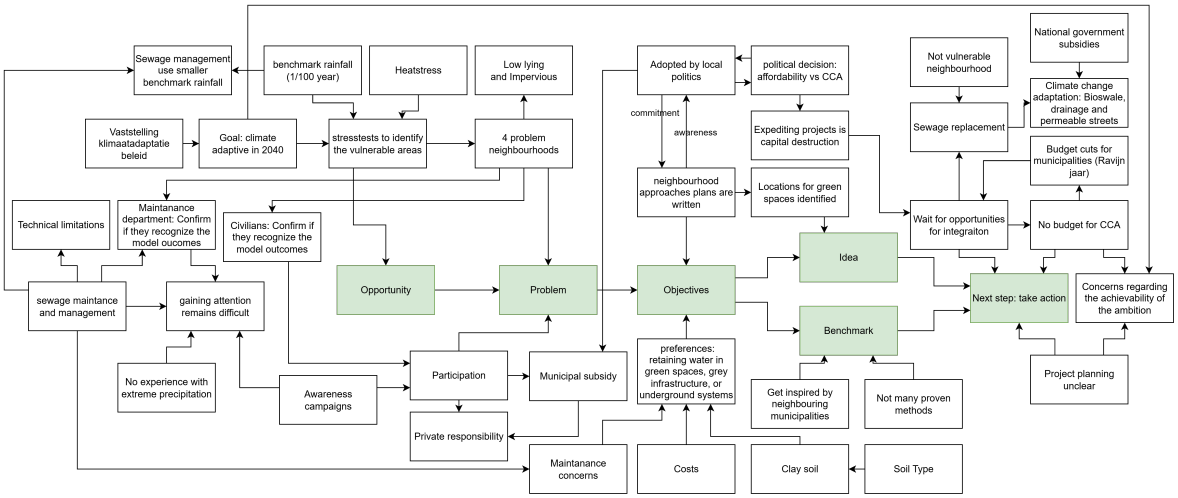


Figure D.6: Process map participant 6

them to identify four problem neighborhoods. That lie low and are impervious. To translate theory into practice, the interviewee went into the streets in these four neighborhoods to talk with residents. Besides he spoke with maintenance staff. The problems were recognized, but it is difficult to have a shared perception of what constitutes an extreme storm. Moreover, the sewer department models using a less intense storm, so there is sometimes skepticism toward the advisor and his 1/100-year storm estimate. Since this municipality has not experienced extreme rainfall, it is hard for both the maintenance department and its residents to imagine such a storm happening.

As part of the spatial program for climate adaptation, risk dialogues have also been established with emergency services, private developers, and housing corporations. Citizens also bear some personal responsibility to make their homes and gardens climate adaptive. They can ask for a municipal subsidy for this.

For all four neighborhoods identified as high-risk, a neighborhood plan has been written with specific goals for what needs to happen in each area. Several challenges arise, such as the presence of a clay soil, which makes infiltration difficult. Additionally, the maintenance costs of the measures should not be too high. These neighborhood plans have been adopted in local politics, both to raise awareness and to ensure that action is no longer optional. In the local politics, there is a trade-off between affordability and climate adaptation, so keeping costs low is important.

To ultimately find solutions based on objectives, the tactics benchmark and idea are used. The neighborhood plans already include locations for green infrastructure, which are based on the idea tactic. The municipality also visits neighboring municipalities to see how they are tackling these issues and to identify approaches that might work for them, this is the benchmark tactic. They find it difficult because there are few proven methods.

The next step for this municipality is to actually start working in one of the four identified problem neighborhoods. The interviewee expressed concern about whether the 2040 climate adaptation goal will be achieved. They need to wait for combined opportunities, because opening up the street earlier than necessary would be a waste of capital. When these opportunities will arise is unclear and possibly far in the future. There is also no dedicated budget available; all measures must be funded through other budget lines. Ultimately, this is a political decision.

There is another neighborhood in the municipality currently being redeveloped. Although it is not a problem area, they are taking the opportunity to immediately install climate-adaptive wadi systems in this neighborhood.

D.7. Participant 7

Participant 7 is a program manager for climate adaptation at a Dutch municipality; the process map is shown in Figure D.7. His role includes integrating climate adaptation into broader urban development programs, such as “Green and Livable X.”

The project discussed was the redesign of a highly paved courtyard from the 1990s. The initiative was triggered by complaints from residents and a housing corporation about heat stress: *“The blinds didn’t melt, but they did warp from the heat.”* The municipality inspected the area and found poor pavement quality and limited tree growth. This led to a redesign focused on greening, water retention, and reducing car dominance: *“We aimed for more greenery, more water storage, and more space for social interaction.”*

The project was initiated based on both resident input and technical assessments. Technical assessment revealed that many objects in the public space were eol. Stakeholders included residents, the housing corporation, and the province (which provided subsidies). The municipality also encouraged the housing corporation to install green roofs: *“We said: if we’re investing in cooling the public space, it’s hard to justify leaving the roofs untouched.”*

Residents were involved early through on-site sessions with visual references. Rather than presenting fixed plans, the municipality asked for preferences: *“We didn’t lay out a blank sheet and say, ‘go ahead.’ We offered reference images to guide the conversation.”* This approach helped manage expectations and align design choices with budget and feasibility. The project was initially ambitious, including bridges over wadi systems. However, cost estimates forced revisions: *“We had to replace the bridges with dam structures because bridges were too expensive.”* Other revisions were considerations on mobility and safety, which also required changes

The city council sets long-term goals, while the municipal executive approves specific projects. The project was paused and revised when costs exceeded the budget, then resumed after adjustments: *“We looked for savings without compromising on ambition.”*

The municipality uses stress tests and a climate adaptation strategy to identify and prioritize vulnerable areas. They have experience with extreme rainfall and see this as a momentum to implement climate change adaptation measures. But they use a programmatic way of working. They aim to align climate goals with planned maintenance: *“We actively look for opportunities to combine climate goals with scheduled work.”* The participant noted a shift in public and political awareness:“Ten years ago, climate adaptation wasn’t even mentioned in our policy documents. Now it’s everywhere.” To increase support, the municipality frames climate adaptation in terms of livability: *“It’s nicer to look out onto greenery than a paved parking lot.”* While the municipality lacks the budget for large-scale innovation, it does experiment with small-scale pilots and design tweaks: *“We try to implement small design changes, like lowering green spaces below street level, at no extra cost.”*

D.8. Participant 8

Participant 8 works at an engineering firm that supports municipalities, provinces, and other public and private entities in understanding and addressing climate risks. While not directly involved in implementation, they play a key role in strategic planning, risk analysis, and the development of decision-support tools for climate adaptation. The process map is provided in Figure D.8

A project discussed was the development of a climate adaptation atlas for a Dutch province and its municipalities. This tool visualizes climate risks (e.g., water logging, heat, drought) using a label system (A–E), where B represents the threshold for climate adaptiveness: *“We defined label B based on national guidelines and local policies. A is better than required, and C to E indicate increasing urgency.”* The atlas helps municipalities prioritize interventions and assess the climate performance of specific streets or neighborhoods: *“It’s like energy labels, but for climate resilience.”* The tool is now in use across multiple municipalities, with varying levels of integration. Some use it to guide street redesigns or to set design requirements for contractors: *“Municipalities can say: we want label B for all indicators in this design.”* However, implementation often runs into budget constraints and constraints in the public available space: *“They come back to us saying: is it even realistic to aim for label B everywhere?”*

Participant 8 emphasized the difficulty of applying national standards, to existing urban areas: *“It’s much*

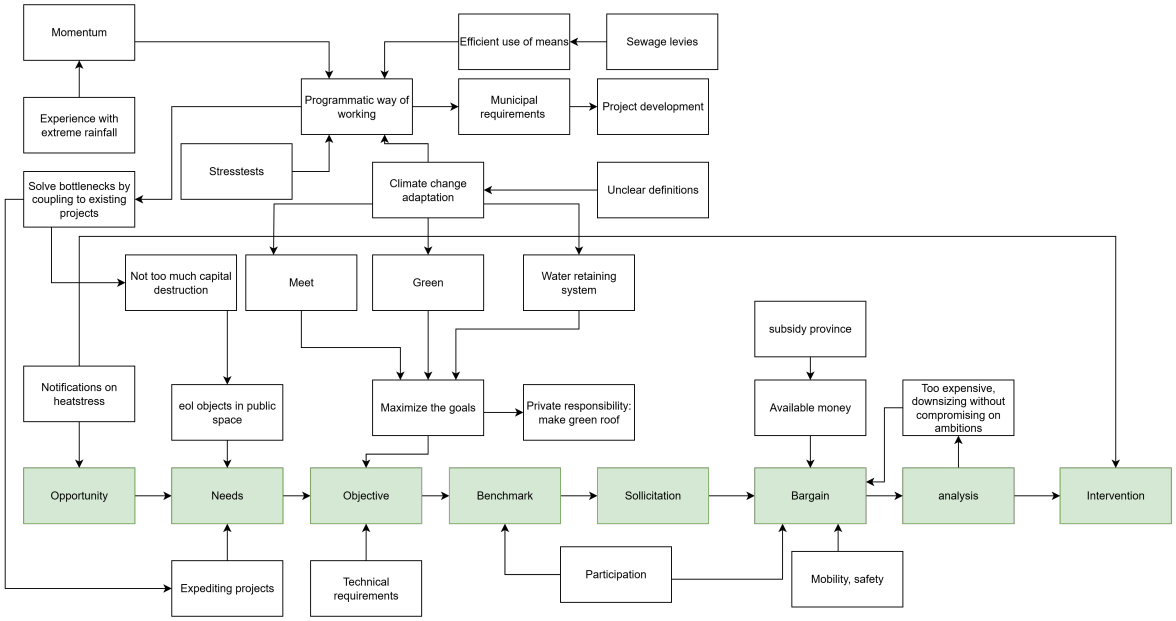


Figure D.7: Process map participant 7

harder to make a dense historic city climate adaptive. Sometimes it's just not technically or financially feasible." In the newly developed area Label B can easier be reached. This has led to discussions about setting more realistic goals, such as improving by at least one label level during renovations.

Cost remains the biggest barrier to implementation. Participant 8 advocates for including impact assessments in decision-making: *"If you don't invest, this is the potential damage in euros, health, and productivity losses."* This helps shift the narrative from "nice-to-have" to essential risk management.

The team is also exploring how to integrate social vulnerability into prioritization: *"Ideally, you'd help the most vulnerable neighborhoods first, not the wealthiest ones."*. This can be done based on demographic signals in a neighborhood or based on income or social housing levels. The interview highlighted the complexity of climate adaptation decision-making, especially in balancing technical feasibility, social equity, political will, and financial constraints.

D.9. Participant 9

Participant 9 is a climate adaptation specialist at a big Dutch municipality, responsible for integrating climate resilience into urban development and infrastructure projects. He also leads data-driven initiatives and policy development, particularly around heat stress. The process map is provided in Figure D.9

A project discussed was the development of two artificial islands in the city, designed to accommodate 8,000–8,500 households, workplaces, and public facilities. The project is unique due to its scale and the opportunity to design from scratch: *"It's a carte blanche in terms of design, urban planning, and technical systems."*

The project was initiated after earlier plans were rejected by the Council of State due to ecological concerns. The revised plan emphasized sustainability and climate adaptation from the outset. Key measures include:

- A groundwater model to determine elevation and prevent flooding.
- Maximized green space and tree planting.
- Use of permeable materials and above-ground water retention.
- A water-retaining road foundation made from recycled materials.

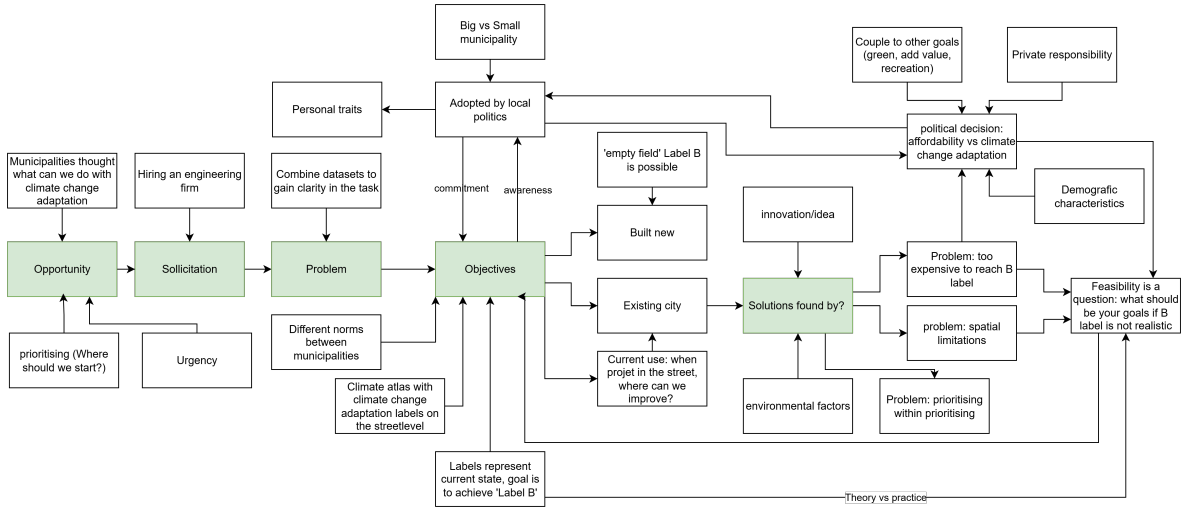


Figure D.8: Process map participant 8

The project distinguishes between two zones: one with suburban-style housing and wadi systems, and another with high-density urban development using innovative underground water storage.

The municipality used climate models, stress tests, and KNMI scenarios to set long-term goals. As the goal is to finish these islands in 2050, future climate scenarios were already considered. These were embedded in the zoning plan. Examples are: *"We aim to store 80 mm of rainwater without damage, exceeding the citywide standard of 70 mm."* Private developers are also required to meet stricter standards, such as mandatory on-site infiltration.

The project involved collaboration with:

- Rijkswaterstaat (land and water ownership)
- Engineering firms (modeling and design)
- Internal departments (urban planning, maintenance)

Multiple design variants were evaluated by a core project team, which included municipal and external stakeholders. The engineering firms were hired, so they would be more convincing towards other departments in the municipality. Furthermore, they are better aware of innovations happening in other municipalities.

The biggest challenge was aligning innovative designs with maintenance requirements and costs: *"Maintenance departments are used to cleaning sewers every few years, not maintaining wadi systems every six months."* Early involvement of maintenance staff and external experts helped overcome resistance and ensure feasibility.

In this case all climate change adaptation goals could be used. Projects in existing neighborhoods are more complex due to:

- Budget constraints
- Existing infrastructure and residents that complain
- Limited space and high groundwater levels in the city

However, the city has shifted toward a risk-based approach using climate risk maps and demographic data to prioritize interventions: *"We now prioritize neighborhoods based on climate risk and social vulnerability."* The city developed its own climate risk maps and adaptation scoring system (1–5), inspired by UNESCO's urban resilience framework. These scores guide investment decisions and are used to estimate required measures and costs. He emphasizes the importance of integrated planning: *"We used to work in silos. Now we're learning that integration is the only way to meet all our sustainability goals."*

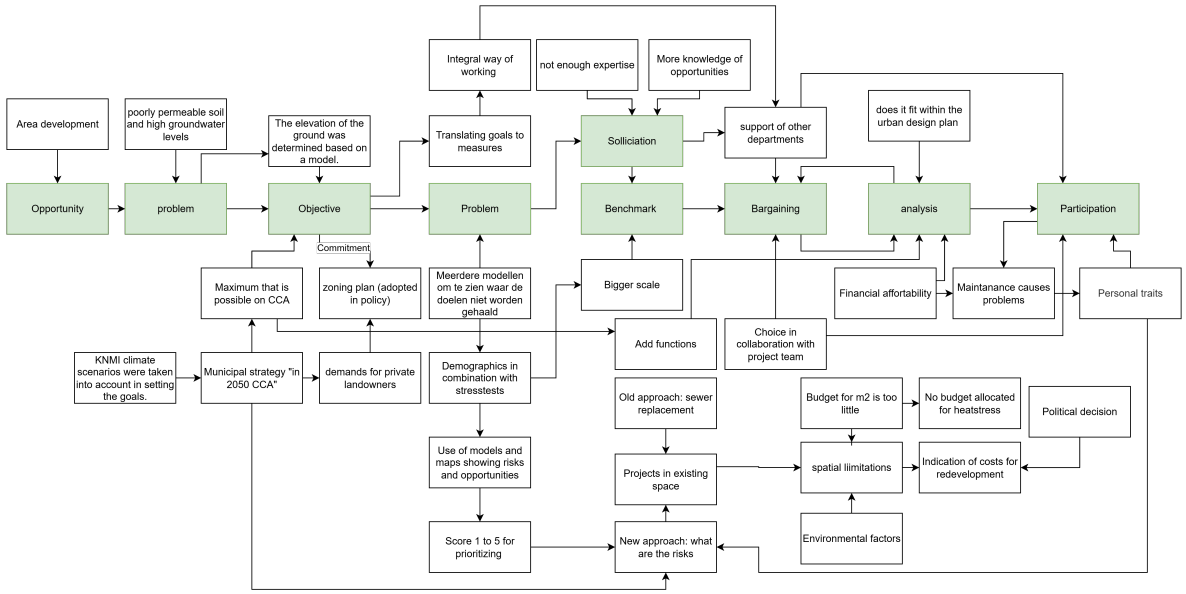


Figure D.9: Process map participant 9

Participant 9 is driven by a desire to make cities more livable for current and future generations: *"I love cities, and I want to make them more livable through climate adaptation."*

D.10. Participant 10

Participant 10 is employed in one of the municipalities that uses the label systematic that was designed by participant 8. Participant 10 is a policy advisor for climate adaptation at a Dutch municipality. His role focuses on translating strategic goals into concrete measures, advising project teams and developers, and integrating climate adaptation into urban planning. The process map is provided in Figure D.10

The interview discusses a project in a low-lying 1960s neighborhood that experienced severe flooding during an extreme rainfall event: *"There was 20 cm of water on the streets, and parquet floors were floating."* This event triggered political urgency and led to a full redesign of the neighborhood with climate adaptation as a core objective. The municipality used a Digital Twin model to simulate the neighborhood and test various climate adaptation measures. The goal was to achieve Label B, a benchmark for climate resilience: *"We modeled the neighborhood, tested different measures, and checked if they met the label B standard."* The Digital Twin allowed iterative testing of interventions like wadi systems, rain gardens, and permeable road foundations. Although the project achieved Label B, it came at a high cost:*"The whole neighborhood cost us €8 million. That's not sustainable for every project."* These high costs were acceptable, because the municipality now uses this project as a pilot to evaluate which measures are cost-effective and scalable.

The project involved:

- Internal departments (green space, traffic, sewer)
- Residents (who responded positively to the plans)
- External engineering firms
- The water board (due to downstream impacts on pumping stations)

"We even got a standing ovation from residents, they were so happy with the plan."

The municipality now integrates climate adaptation into all streets and sewer renovations. A dedicated annual budget of €1–2 million supports these efforts: *"Every time a street is opened, we include climate adaptation."* However, the participant noted that Label B is not always feasible, and that cost remains the biggest barrier. The city uses a label map to identify vulnerable areas and prioritize interventions.

The label system was developed in collaboration with other municipalities and advisory firms to make climate adaptation more quantifiable: *"Climate adaptation used to be a vague concept. Now we can measure it."*

The Digital Twin also includes heat stress modeling. Drought and flooding are excluded, as they fall under the jurisdiction of the province and water boards.

Participant 10 is passionate about the tangible impact of his work: *"You can't stop climate change, but you can adapt to it. That's what makes this work meaningful."*

The participant is critical of inefficiencies in government:

- Large municipalities & central government suffer from long communication lines.
- Outsourcing leads to knowledge loss and high costs.
- National coordination is lacking.

"Every government level is reinventing the wheel. It could be so much more efficient."

D.11. Participant 11

Participant 11 is a senior advisor for water and climate at a Dutch municipality. He is responsible for implementing the municipality's integrated Urban Water Plan, which combines the sewerage plan, groundwater policy, surface water policy, and climate adaptation strategy into one overarching framework with four execution programs. The process map is provided in Figure D.11

The participant described a redevelopment project in a 1980s neighborhood involving both public and private space. The project includes:

- Demolition of outdated housing
- New residential development
- Sewer replacement
- Climate adaptation measures

The goal was to achieve a negative hard surface balance (i.e., more green space than before) and retain all rainwater on-site: *"We aim for a water-neutral area where all rainfall stays within the site."*

Measures include:

- Wadis, water squares, and underground crates
- Green roofs and water-retaining roofs
- Shading to reduce heat stress
- 70 mm rainwater retention on private plots (as per the municipality's stormwater ordinance)

All measures were tested using stress tests and incorporated into a Program of Requirements for the Living Environment, which applies to both public and private domains. For every project that is done, it is tested whether the goals are met, based on the measures that are implemented. It is an obligation. /

The municipality uses GIS-based neighborhood factsheets that compile data on:

- Water system analysis
- Groundwater levels
- Heat islands
- Green space availability
- Foundation damage risks

These factsheets guide project teams and ensure that climate adaptation is integrated into every redevelopment: *"We automated the data so that every project leader knows what needs to be done."*

Funding for climate change adaptation comes from:

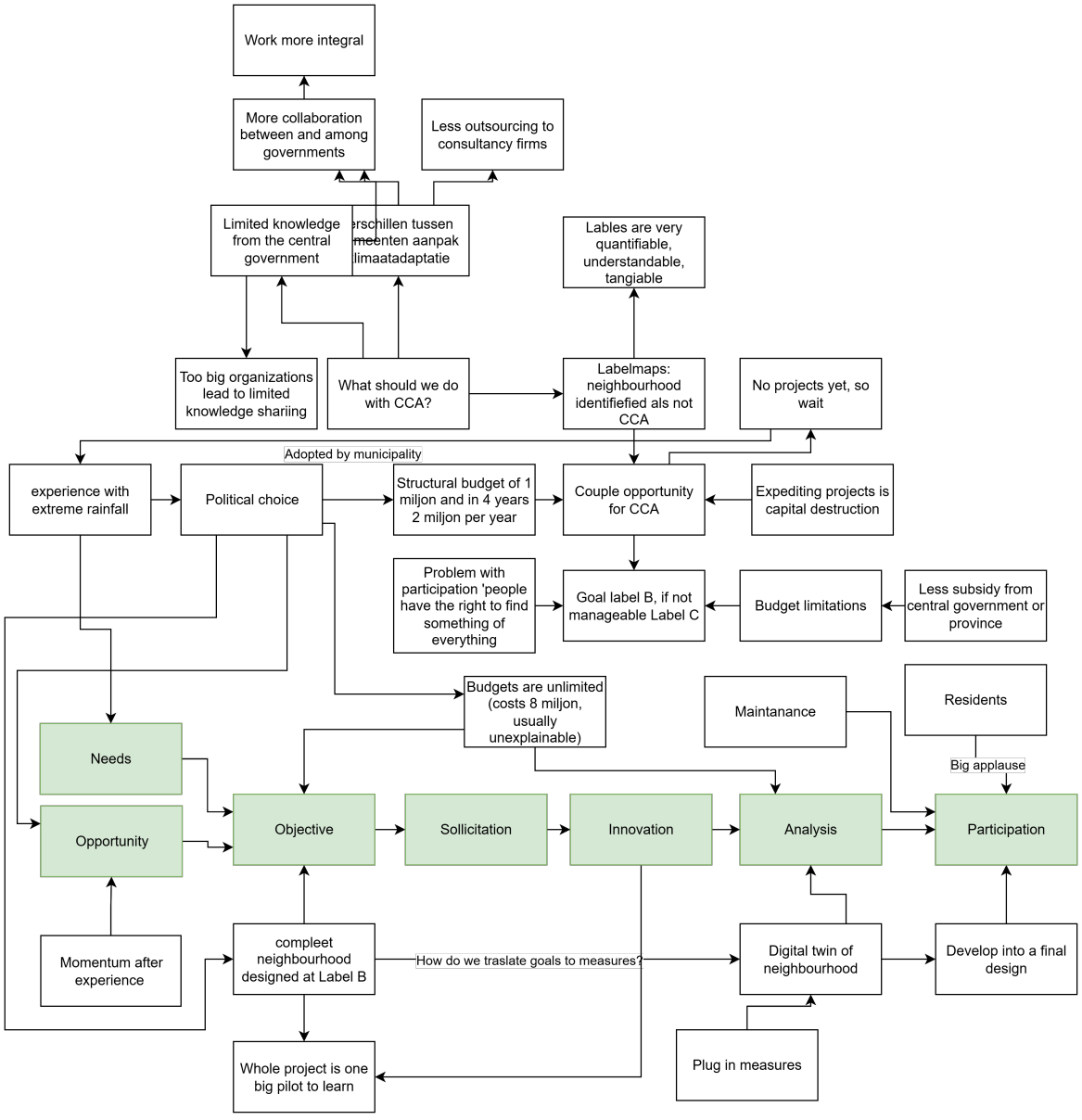


Figure D.10: Process map participant 10

- Sewer levies (for water-related measures)
- General municipal funds (for greening)

The participant emphasized that execution capacity is a bigger bottleneck than funding *"We have the money, but we can't spend it fast enough due to delays and coordination issues."*

The project involved:

- Landscape architects
- Urban planners
- Technical advisors
- Developers
- Internal departments (e.g., mobility, green space)

Political decisions were required when trade-offs arose, such as between parking and green infrastructure: *"If it comes down to ten parking spots or a wadi, the political choice is often parking."*

Participant 11 is driven by a desire to make the city more livable and inclusive: *"I want everyone to feel at home in the city, not just the wealthy."*

He sees climate adaptation as a way to improve urban quality of life and reduce inequality.

The participant highlighted several systemic issues:

- Split incentives: Municipalities bear the cost of adaptation, while insurers and health systems benefit.
- Political influence: Decisions often depend on the political climate and public opinion.
- Knowledge fragmentation: Large municipalities and national agencies suffer from poor internal communication.

D.12. Participant 12

Participant 12 is a senior policy advisor for urban water, sewer systems, and climate adaptation at a Dutch municipality. He also works within a regional collaboration involving municipalities, the water board, and the province. The process map is provided in Figure D.12 . The municipality's climate adaptation efforts were catalyzed by an extreme rainfall event in 2010. This led to the development of:

- Improved sewer modeling
- A risk-based management approach
- A comprehensive Water and Climate Adaptation Plan (2022–2026)

The municipality uses risk acceptance thresholds to prioritize interventions. Locations with the highest risks are addressed autonomously, while others are tackled through opportunity-based integration with planned infrastructure works. The prioritization is done based on: *"We prioritize based on risk level, cost-efficiency, and whether we can align with other planned works."* to come up with measures it remains important to consider:

- Local spatial constraints
- Technical feasibility
- Cost
- Opportunities for co-benefits (for example, heat mitigation, biodiversity)

Examples include:

- Wadis and open water systems
- Underground storage (if space is limited)
- Reopening historical streams where possible

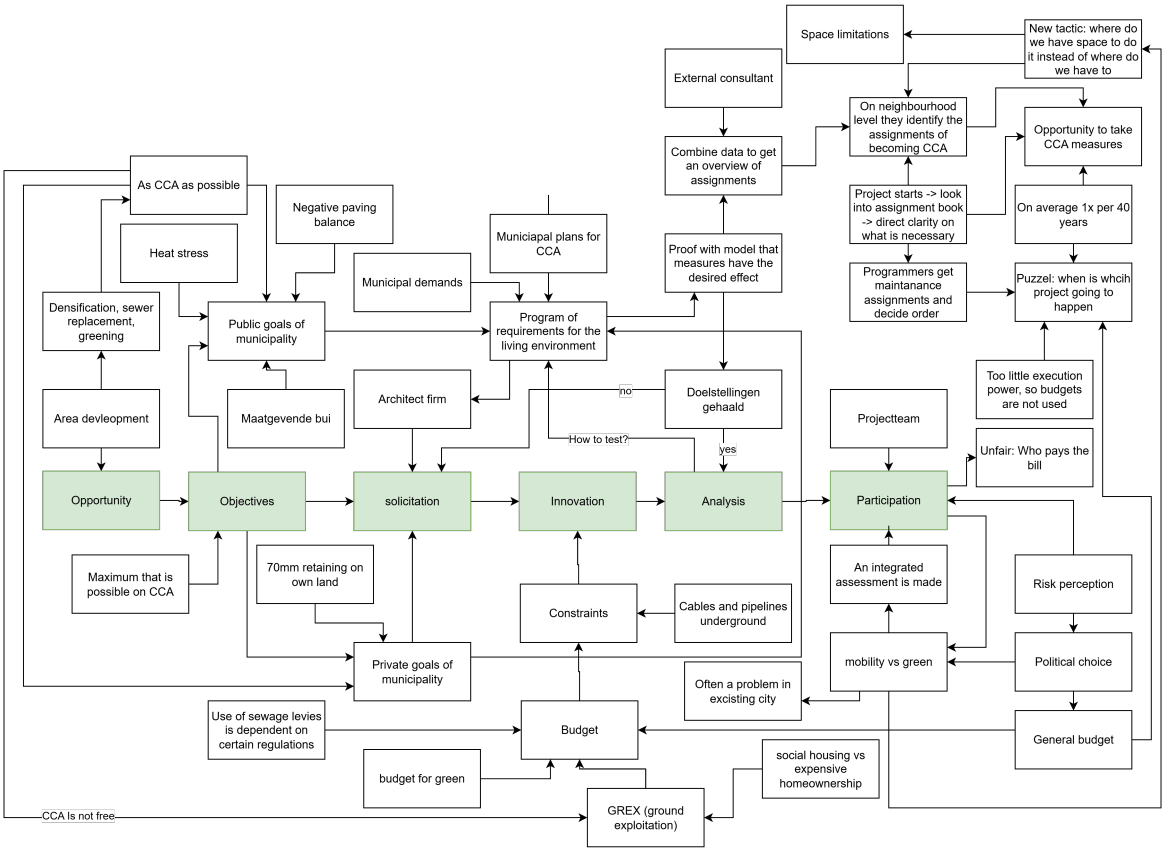


Figure D.11: Process map participant 11

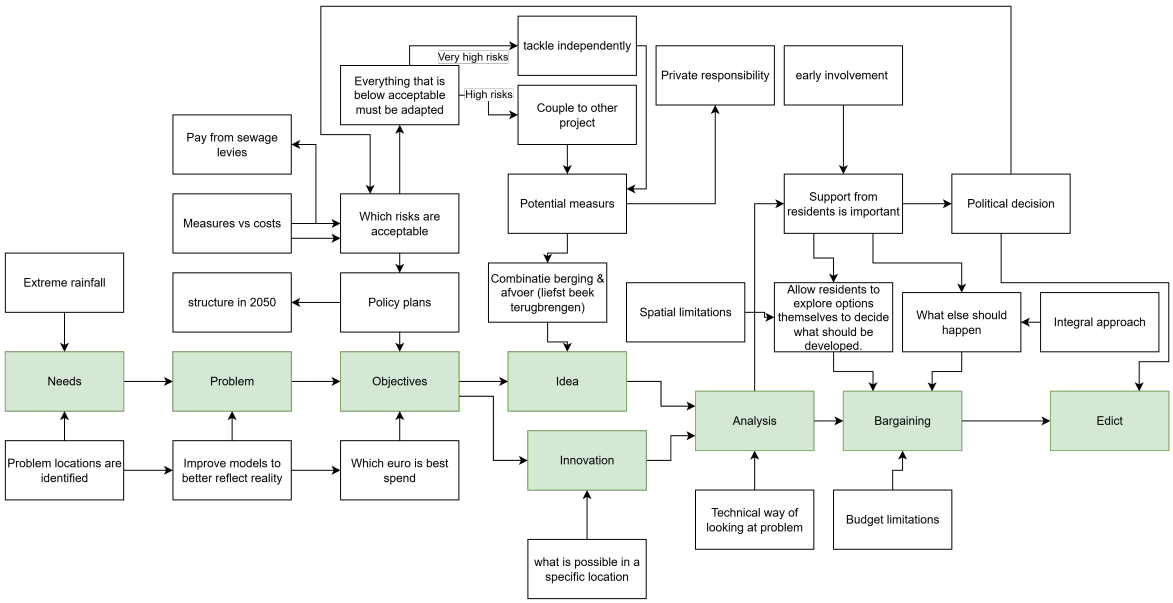


Figure D.12: Process map participant 12

The municipality also uses GIS-based neighborhood fact sheets to guide design and planning. The municipality involves residents through participation early. *"We involve residents early, using tools like magnetic street profiles to help them understand trade-offs."* The reason for this is that in this way they better understand the limited space and tradeoffs that the municipality has to make within this. Political support is essential, especially when public resistance arises. For example, a project to reintroduce a stream was only approved after residents supported it through participatory planning. Funding for climate change adaptation comes primarily from:

- Sewer levies (for water-related measures)
- General municipal funds (for greening)

The municipality has negotiated with the city council to adjust risk acceptance thresholds and align them with available budgets:*"Lowering the risk threshold means more measures, and more funding via the sewer levy."* The municipality uses external engineering firms to develop and maintain sewer models. These models are used to:

- Identify high-risk areas
- Simulate the impact of proposed measures
- Ensure compliance with risk thresholds

The city is working toward a 2050 climate-resilient vision, aligned with the national Delta Program. This includes:

- Green-blue structure plans
- Integration with energy transition and mobility plans
- Future-proofing infrastructure even if full functionality is delayed

"We prepare infrastructure now so it can be connected later when the rest of the system is ready."

Participant 12 wants to create a livable, inclusive, and future-proof city: *"I don't live here, but I do this for the people and businesses of this city, to keep it livable for everyone."*

D.13. Participant 13

Participant 13 is a strategic advisor for spatial planning at a Dutch water board. His role focuses on integrating water-related interests, such as including climate adaptation, water quality, and flood safety,

into municipal and provincial spatial plans, as well as internal water board regulations.

The water board organizes climate adaptation through a dedicated program, which includes sub-programs for urban areas, rural areas, and internal operations. The participant is primarily involved in urban development and spatial planning: *"We aim to be involved as early as possible in municipal planning processes."* The water board provides input during early planning stages, Environmental plan development and Water permits. He sees the water board as a proactive player in spatial planning and climate adaptation: *"We want to take more initiative at the spatial planning table than many other water boards."*

An example discussed was an area development project near a municipality. The water board advised on:

- Managing increased runoff due to added impervious surfaces
- Maintaining flow in existing watercourses
- Integrating climate adaptation into the spatial plan

"We provide guidelines, and the developer calculates how to meet them. We then assess whether the plan is acceptable."

The water board's influence is strongest at two points in the early advisory phase (to shape plans and involve interests before they are fixed) and in the permit phase (where legal requirements must be met).

The water board supports climate adaptation through:

- Subsidies (e.g., impulse programs for municipalities)
- Blue citizen initiatives (for private adaptation)
- Internal integration (e.g., climate-proofing water treatment facilities)

Challenges the waterboard faces are:

- Limited influence on small-scale municipal projects (e.g., street redesigns without permits)
- Variability in municipal capacity and ambition
- Fragmented responsibilities in small municipalities (e.g., outsourced planning staff)

An example is provided by: *"In small municipalities, continuity is often lacking because key roles are outsourced."*

The participant emphasized the need to balance multiple goals:

- Climate adaptation
- Water quality
- Flood safety
- Groundwater management

Sometimes these goals conflict, such as raising groundwater levels to prevent subsidence versus increasing flood risk:*"We try to calculate where the pain points are and design local solutions accordingly."*

Participant 13's motivation stems from personal experience with flooding in 1995 and a desire to contribute to safer, more resilient communities.

E

Overview of maps

Figure E.1 shows for every participant the nutt framework tactics that were identified in the interviews. Furthermore, Table E.1 and Table E.2 show the raw interview data of the identified process.

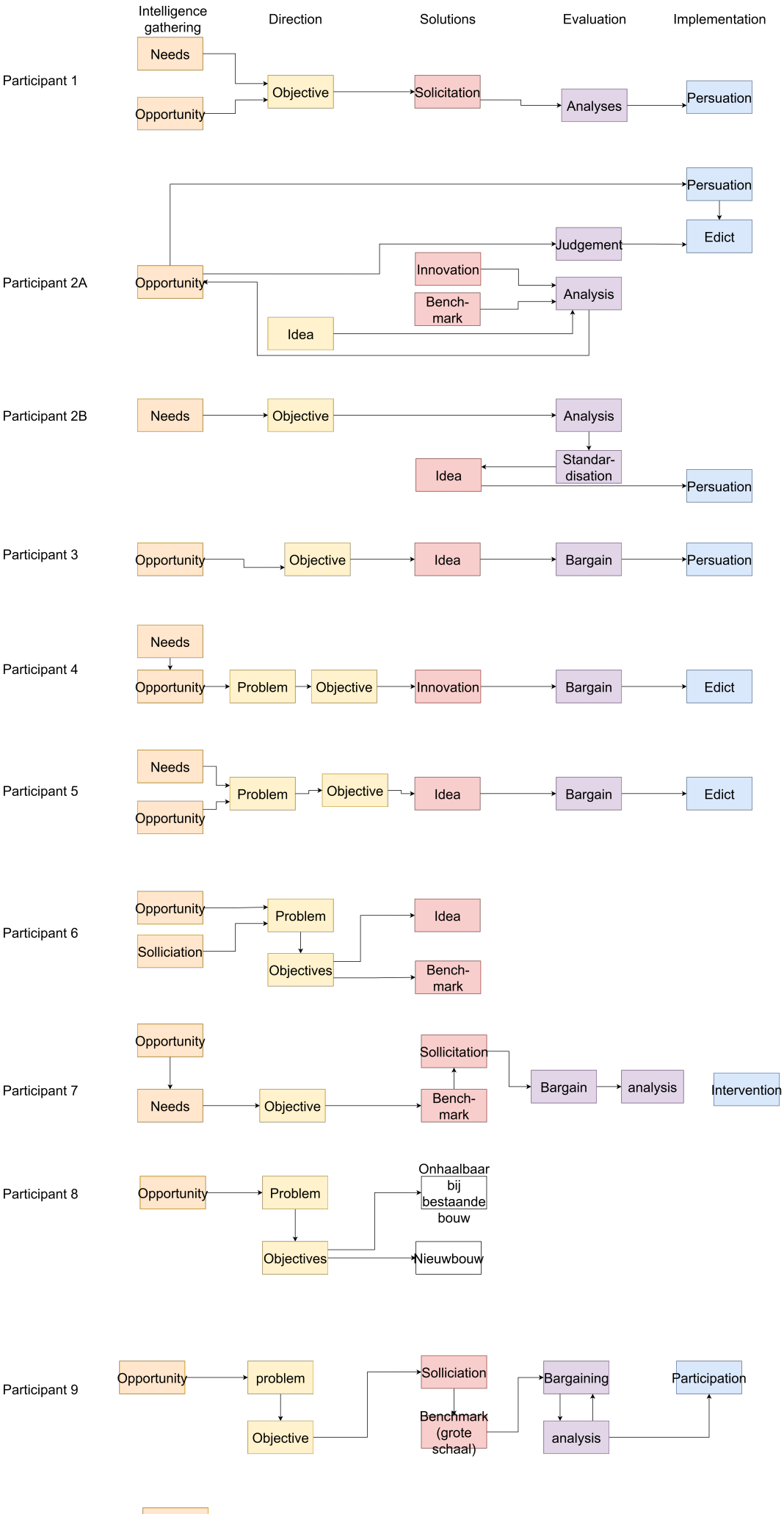
Table E.1: Overview of tactics used by participants in the intelligence gathering, directions from and solutions found by phases of Nutt's model. 1 represents that the tactic was named.

Part.	**Intelligence Gathering**		**Directions from**			**Solutions found by**			
	Needs	Opportunity	Idea	Problem	Objective	Idea	Benchmark	Solicitation	Innovation
P1	1	1			1			1	
P2A		1	1				1		1
P2B	1				1	1			
P3		1			1	1			
P4	1	1		1	1				1
P5	1	1		1	1	1			
P6		1		1	1	1	1		
P7	1	1			1		1	1	
P8		1		1	1				
P9		1		1	1		1	1	
P10	1	1			1			1	1
P11		1			1			1	1
P12	1			1	1	1			1
Totaal	7	10	1	6	11	5	4	5	5

When they are sorted by municipal size, different patterns also emerge, this is shown in E.2, which are sorted by big municipalities and E.3 which sorts the medium and small municipalities

Table E.2: Overview of tactics used by participants in the evaluation and implementation phases of Nutt's model, 1 represents that the tactic was named.

Part.	**Evaluation**				**Implementation**			
	Analysis	Bargain	Judgment	Subjective	Persuasion	Edict	Participation	Intervention
P1	1				1			
P2A	1		1		1	1		
P2B	1				1			
P3		1			1			
P4		1				1		
P5		1				1		
P6								
P7	1	1						1
P8								
P9	1	1					1	
P10	1						1	
P11	1						1	
P12	1	1				1		
Total	8	6	1	0	4	4	3	1


Intelligence gathering
Direction
Solutions
Evaluation
Implementation
Participant 1
Needs
Opportunity
Objective
Solicitation
Analyses
Persuation
Participant 2A
Opportunity
Idea
Innovation
Bench-mark
Analysis
Judgement
Edict
Persuation
Participant 2B
Needs
Objective
Analysis
Standar-disation
Idea
Persuation
Participant 3
Opportunity
Objective
Idea
Bargain
Persuation
Participant 4
Needs
Opportunity
Problem
Objective
Innovation
Bargain
Edict
Participant 5
Needs
Opportunity
Problem
Objective
Idea
Bargain
Edict
Participant 6
Opportunity
Solliciation
Problem
Objectives
Idea
Bench-mark
Participant 7
Opportunity
Needs
Objective
Bench-mark
Sollicitation
Bargain
analysis
Intervention
Participant 8
Opportunity
Problem
Objectives
Onhaalbaar bij bestaande bouw
Nieuwbouw
Participant 9
Opportunity
problem
Objective
Solliciation
Benchmark (grote schaal)
Bargaining
analysis
Participation

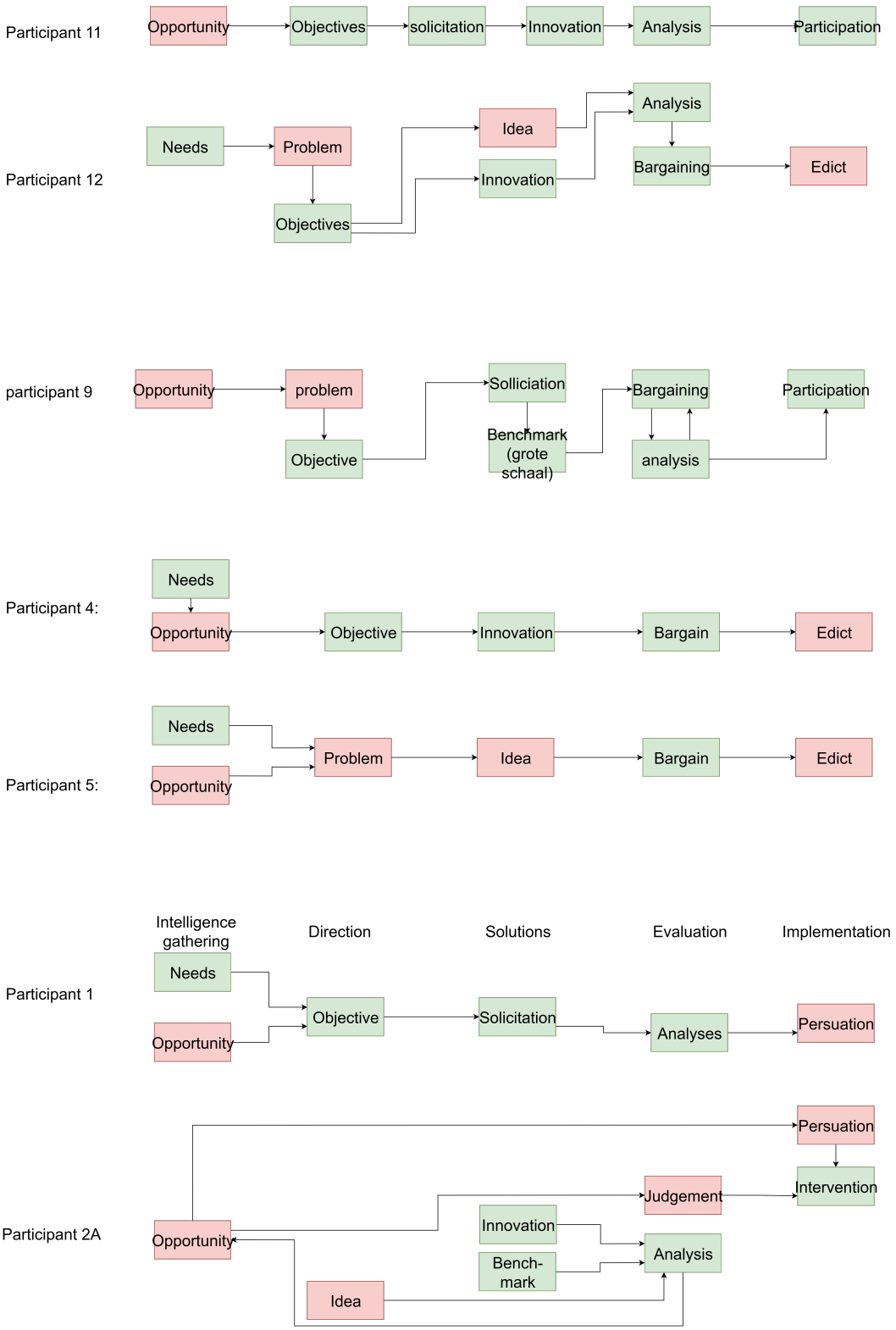


Figure E.2: Nutt framework tactics big municipality

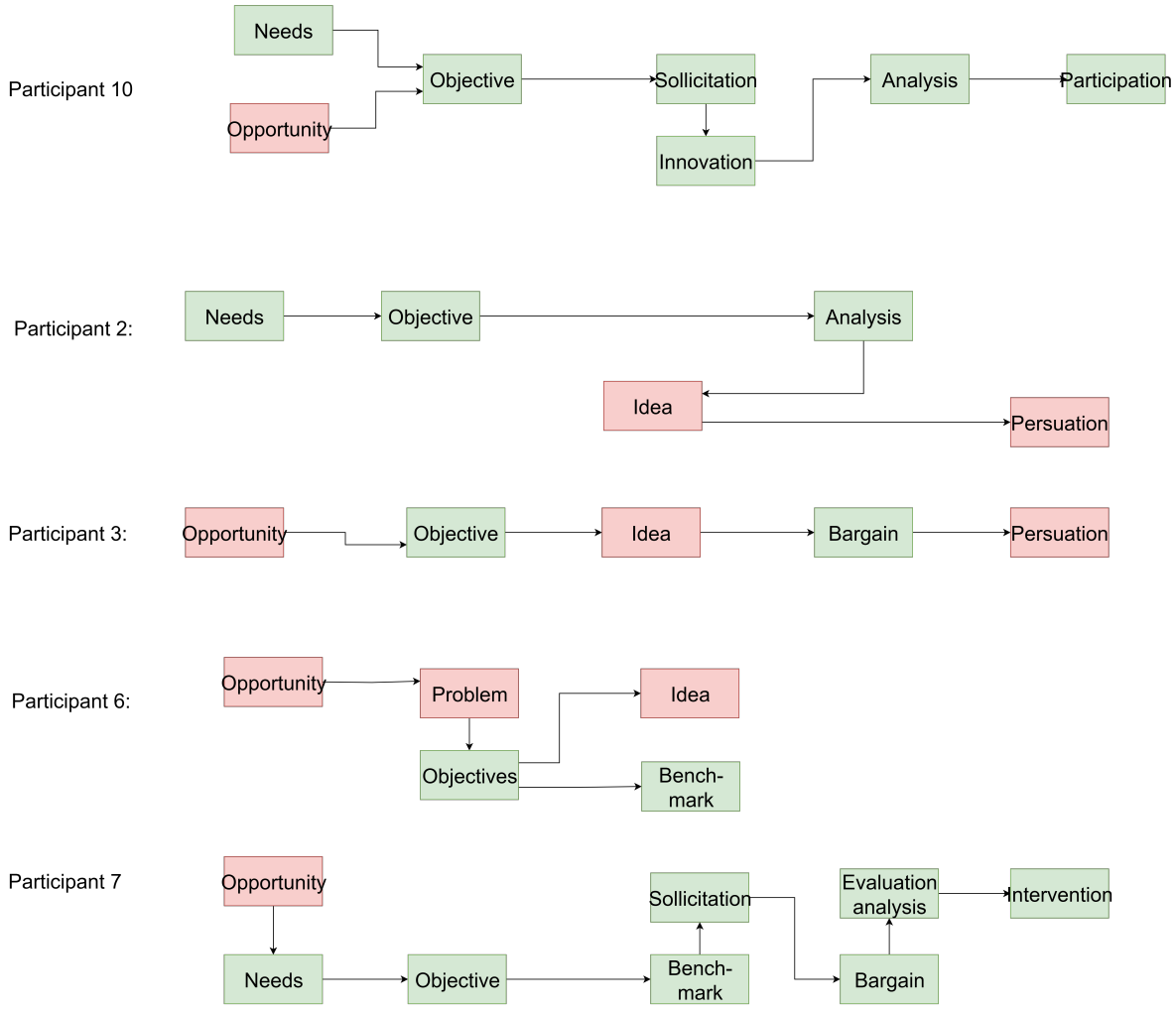


Figure E.3: Nutt framework tactics medium and small municipality