Climate Model Results: Optical Solution or Illusion?

A case study on the visual framing effects of extreme rainfall model results on the interaction between municipal actors

Sophie van Rijn, 2021

The cover shows the author looking through a visual frame of the extreme rainfall model results at the Stationsweg, the main street in the Huygenspark neighbourhood. This street was characterised by a large amount of water nuisance in the model. The picture is taken by the author.

Climate Model Results: Optical Solution or Illusion?

A case study on the visual framing effects of extreme rainfall model results on the interaction between municipal actors

By

Sophie van Rijn

in partial fulfilment of the requirements for the degree of:

Master of Science

in International Land and Water Management (Specialisation: Adaptive Water Management)

at the Wageningen University & Research

and in partial fulfilment of the requirements for the degree of:

Master of Science

in Science Education and Communication (Track: Communication Design for Innovation)

at the Delft University of Technology
to be defended publicly on the 27th of August 2021 at 11:00 AM

Thesis Committee

Adaptive Water Management

Supervisor: Dr. Saskia Werners
Water Systems and Global Change

Committee Member: Dr. Raffaele Vignola
Water Systems and Global Change

Communication Design for Innovation

Supervisor: Dr. Maarten van der Sanden
Communication Design for Innovation

Mentor: Drs. Caroline Wehrmann
Communication Design for Innovation

Committee Member: Dr.ir. Martine Rutten
Water Management

Committee Member: Prof.dr. Marc de Vries
Communication Design for Innovation

An electronic version of this thesis is available at *http://repository.tudelft.nl/*

WAGENINGEN UNIVERSITY & RESEARCH

TU Delft

Acknowledgements

With this extensive amount of pages, I finish my year of thesis and am one step closer to finishing my two master's degrees in International Land and Water Management and Communication Design for Innovation. This thesis gave me the possibility to dive into both study fields, to find the richness of both perspectives, while having the freedom to explore my own interests. It certainly has been a rollercoaster of challenges, contrary perspectives and possible researchable options, but I can definitely say that I am proud of the work that lays in front of you. This result would not have been there without the people that have helped and supported me throughout this year. I would like to thank a few specific persons that have helped me a great deal along the way.

I want to thank my diverse group of four supervisors. First, I would like to thank Saskia Werners for her sharp feedback which kept me grounded in the whirlwind of theories and concepts, as well as her positive energy and critical notes that really brought my project to the next level. On a more personal note, I will also definitely remember to follow your metaphor of the broken bike against a dyke more often. Besides, I would like to thank Maarten van der Sanden for his flexibility to pick up my project halfway and since then bringing so much richness to the project through his creative, out of the box, ideas and input every session. In addition, my gratitude goes to Martine Rutten and her ability to help me build (and perhaps be) the bridge between water management in Wageningen and communication sciences in Delft. I have really appreciated your critical reflections, knowledge of both fields, the personal supervisor sessions at Bouwcampus and Labs, and connecting me to various students in climate change adaptation through the Delta Futures Lab. I would also like to thank Caroline Wehrmann, though only seen sporadically, I always knew that if I had issues or needed more support I could reach out to you.

Next, I would also like to thank all the municipal actors at the Municipality of The Hague that I interviewed over my year of work. You always showed so much positivity and interest in my work that it always made me feel that I was working on something important. Last but definitely not least, I would also like to thank my friends and family for their endless patience and support. My parents for checking up on me and believing in me, and especially the friends that were there with me every day in the "afstudeerhok", those that helped me read through some chapters in the last few days (or nights), those that send me motivational speeches through text (or GIF) and those that managed to pull me out of my graduation bubble from time to time. I am grateful to all of the above and I hope you enjoy reading this final work.

Sophie van Rijn

Delft, 25th of July 2021

Abstract

In the Netherlands, the frequency and severity of extreme rainfall events are expected to increase. This can result in severely detrimental effects. It is complicated for municipal actors to effectively manage these events, as it requires judgement on probabilities, costs, and uncertain impacts. As a result, obtaining scientific knowledge through climate tools and model results has become increasingly important in informing policy-making processes. While model results and climate tools have been shown to create an imperative to act for municipal actors, a clarification of how a certain approach might offer support in a specific context is scarce. By simplifying model simulations for municipal actors, information gets lost and becomes (unconsciously) framed, leaving room for the personal interpretation of municipal actors. Framing can change the actor's perception without altering the scientific information they were initially provided, which might result in different decisions taken on water management. Decision-making is not an individual process. It involves interaction between a multitude of stakeholders of various disciplines, all with own individual contextual factors. It is essential for effective decision-making on extreme rainfall events that interaction is well-coordinated.

This integrated master thesis for the master's degrees in International Land and Water Management and Communication Design for Innovation, therefore, aims to explore the influence of visually framed extreme rainfall model results on the interaction between municipal actors. This is explored in the Municipality of The Hague and the Huygenspark neighbourhood. The model results have been adjusted to two contrasting frames: in terms of gains or losses and psychological distant or near impacts.

These two contrasting frames have resulted in the development of four visually-framed extreme rainfall model results, hereafter named maps. For the distant loss map, water nuisance has been assessed in the Tygron Geodesign Platform. The water nuisance map shows that especially the Stationsweg, the tunnel at the Rijswijkseweg, and the tunnel underneath the train tracks will have water nuisance issues during extreme rainfall events. For the near loss map, the framing of adaptation tipping points has been applied. Adaptation tipping points frame the issue from the socio-political objectives and show the moments in time at which a change in the current management strategy no longer meets the municipal actors' objectives. The socio-political objective has been identified to focus on maintaining the accessibility of roads for cars and ambulances. The model shows that the Stationsweg and the tram tunnel cross this threshold during a once a 25 years rain shower (40 mm/hour), while the Rijswijkseweg tunnel reaches the threshold already at a rain shower of less than once a 10 years (30 mm/hour). This return period will become more frequent to once every 13 years and an unspecified low non-extreme return period in the upper scenario of 2050 respectively. The two main chances to tackle this issue are either spatially, in the Oranjeplein and Huijgenspark or through adaptation mainstreaming opportunities.

The four maps were interpreted by fourteen municipal actors within the Municipality of The Hague through semi-structured interviews. Visual framing was found to have a profound effect on the interpretation of municipal actors. The near-framed adaptation tipping points map made the issue more concrete and expressed urgency as well as the necessity to take action compared to the distant-framed water nuisance map. The chance maps created a more positive interpretation than the loss maps. Besides, the interpretation of maps was also determined by the pre-existing knowledge structures and ways of looking at the issue, resulting in three distinct interpretations for the adaptation tipping points map. While every map has its own main interpretation, most municipal actors emphasised that the maps should be combined to create an overall story. This story can be used during interaction to convince others, but it can also be to start a discussion or to weigh different options. The visual maps can, therefore, be seen as a *'story support tool'* for interaction.

Table of Contents

1

Introduction

> *"Tens of deaths in our neighbouring countries, houses standing underwater, and roads changing into rivers. We are not used to these kinds of situations in Western Europe, but they have become our reality now. Is this a taste of what is waiting for us in the future?"* (RTL Nieuws, 2021)

At this very moment of writing, at the end of July 2021, extreme rainfall has resulted in overburdened sewage systems and peak discharges in the Meuse and Rhine rivers, leading to deaths in Germany and Belgium as well as a path of economic and social destruction in the Netherlands. The distant, intangible, problem of extreme rainfall events without a single geographic location or timeline is not so distant anymore. Its destructive consequences were right here; in Limburg, the Netherlands. Inhabitants, municipal actors and researchers have started to raise questions: How are we to prepare for the uncertain future? How can we incorporate these low probability risks with severe impacts? And if we want to prepare for the future, is scientific knowledge through climate tools and models the solution to well-informed policy choices?

These questions signify the focal point of this work. This thesis is a combined study for the two master's degrees in International Land and Water Management at the Wageningen University & Research and Communication Design for Innovation at the Delft University of Technology. Consequently, this study combines concepts and perspectives of both fields. In line with this, this chapter provides an introduction to this thesis from both disciplines. The first section sets the context of this study, starting from the field of water management (Section 1.1) and extending into a communication sciences perspective (Section 1.2). This is followed by the formulation of the research problem (Section 1.3), the case study description (Section 1.4), research objectives (Section 1.5) and the research questions (Section 1.6). The chapter is finalised by an outline of the structure of the report (Section 1.7).

1.1 Water Management Context

While the flooding event in Limburg was a once-in-hundred-years rainfall event, studies have shown that with every degree Celsius of increase in temperature, extreme rainfall events are expected to increase by approximately 14% (Lenderink & van Meijgaard, 2008). This will result in an increase in the risk of flooding (IPCC, 2014). This increased risk may especially have large consequences for urban areas, due to the larger percentage of paved surfaces and relatively low amount of green space, allowing little rainwater to infiltrate the surface (OECD, 2014). As a result, excess water must be drained by traditional drainage systems, which in the Netherlands, is mainly through sewerage systems and canals. Currently, most sewage systems in the Netherlands cannot handle these types of extreme rainfall events (Dai et al., 2018), leading to pluvial floods (rainfall-induced surface water or flash floods). While pluvial floods are characterised by a low water depth compared to coastal or river floods, the current pluvial floods show that they can result in serious socio-economic consequences. These include the destruction of buildings and interiors (Albers et al., 2015), causing power or telecom cuts, and interruptions of

traffic and businesses. Dutch newspapers, therefore, write about a "wake-up call" to improve water resource management and spatial planning (e.g. Hoogheemraadschap van Delfland, 2021; Houthuijs, 2021).

However, dealing with water resources and spatial planning becomes increasingly challenging for municipal actors as they are faced with a multitude of uncertainties. On the one hand, municipal actors must account for the unknown magnitude and impacts of extreme rainfall events (IPCC, 2014). This requires evaluation and judgement of probabilities and risks whilst narrowing down the complexities of future climate projections. On the other hand, these impacts are influenced by uncertain socio-economic developments (Dewulf & Termeer, 2015). Societal perspectives and preferences may shift over time (Offermans, n.d.), changing the perception of whether an outcome is acceptable or not and which approach or strategy is deemed appropriate. This is exacerbated by uncertain demographic and economic trends. Despite these uncertainties, delaying a decision, which is a common response of municipal actors when facing uncertainties (e.g. Adger et al., 2011; Eriksen et al., 2011), is troublesome due to the possibly major consequences. This pressure to take immediate decisions to prevent and account for these uncertain consequences poses complex challenges for municipal actors in coming to a sustainable or 'good' decision.

In light of these complexities, scientific knowledge has become a crucial element in informing policy-making processes. An important way to convey scientific information to municipal actors is through climate tools and visualisations, e.g. through climate model results, graphics and photographs. Climate tools translate global climate data into practical scale-specific information to manage local, regional or national risks and opportunities. Currently, there is a large variety of tools to support decision-making on climate change adaptation, from 'climate stress tests' in the Dutch Delta Programme (Delta Programma, 2017), focused on top-down conveying information about vulnerability into climate model results, to more decision-focused or bottom-up approaches such as adaptation pathways (Haasnoot et al., 2013) and adaptation tipping points (Kwadijk et al., 2010). These bottom-up approaches, such as adaptation tipping points, can incorporate robustness and flexibility into decision-making, by showing trade-offs, preventing lock-ins and creating awareness of the threshold effects (Butler et al., 2016; Stanton & Roelich, 2021).

Adaptation tipping points have expanded in academic literature as a promising tool to frame and inform municipal actors. These points are moments in time when a change in environmental or social conditions causes the current management strategy to no longer meet the objectives (Kwadijk et al., 2010) and action is necessary to remain within the limits of the objectives. These objectives can be based on technical or biophysical conditions, for example, *"the maximum annual rainfall (mm/year) beyond which the particular action will cease to perform as expected and will cause flooding"* (Manocha & Babovic, 2017, p.89), but can also be determined by social or economic conditions, e.g. *"maintaining a minimum average beach width of five metres from sea wall"* (Ramm et al., 2018, p.14). Adaptation tipping points, therefore, frame the issue in terms of the functionality of the system and the potential system failure instead of the change in climate pressures and impacts (Werners et al., 2015). Instead of asking "what happens when a certain scenario occurs?", adaptation tipping points focus on "under what conditions will a given plan fail?". This assessment is coupled with a time component to show the municipal actors their window of opportunity to stay within the limits of the stated objects.

However, while such climate model results have shown abilities in creating an imperative to act, discerning its effects in specific contexts is scarce (e.g. Kwakkel & Haasnoot, 2019; Lin et al., 2017). During the development and validation of the tools, the focus is often on whether these tools improve the formation of a robust or adaptable approach, but not how these approaches might be implemented

by specific actors in a certain context (Lawrence & Haasnoot, 2017). This context is often overlooked, despite evidence showing that the specific context on individual, organisational and institutional levels influence the extent to which a tool can be implemented in practice (Stanton & Roelich, 2021). Especially on the individual level, case studies often give little consideration to the actors themselves and assume that they act rationally (Stanton & Roelich, 2021).

1.2 Communication Perspective

The study's perspective is through the lens of cognitive sciences, which focuses on behaviour through an individual's mental processes. The study has started from the concepts of cognitive biases and framing and has extended throughout the research towards the concepts of visual framing and interaction. This section follows this line of thought.

From a cognitive sciences perspective, seeing the municipal actors as rational agents is limited, as an actor's decision under uncertainty is highly subjectable to their expectations, experiences, norms and habits. Through numerous controlled experiments, Kahneman and Tversky (1979) showed that people violate the most basic assumptions of rational decision-making. Instead, they present the concept of *cognitive biases*. Cognitive biases are systematic errors in judgement when processing or interpreting information, causing the individual to deviate from rational decision-making. As a result of these systematic errors, individuals rely on mental shortcuts, heuristics, to solve problems and to make judgements on probability and risk quickly and efficiently (Tversky & Kahneman, 1974).

Unconsciously framing the issue through climate model visualisations and adaptation tipping points, plays into these cognitive biases and mental short-cuts by highlighting certain elements. This way, framing can change the decision-maker's perception without altering the scientific information initially provided. Climate tools and model visualisations in particular have the unique character to portray a certain reality. They help municipal actors to picture the vague and abstract reality of climate change. Nevertheless, as there is only limited room in one visual image, a complex issue such as climate change cannot be projected in its entirety. Visual communication, therefore, requires a wide array of choices to be made. This implies visual images cannot show an 'objective reality', but rather a particular way of seeing the world.

While *visual framing* has increasingly become the object of analysis (e.g., O'Neill, 2013; Rose, 2016), geographers still consider visuals as a relatively under-researched section of climate sciences (e.g., Bell et al., 2001; Moser, 2010). Previous studies have mostly focused on the framing of static images in the media (e.g., O'Neill & Smith, 2014) or in scientific reports (e.g., Wardekker & Lorenz, 2019). Through content analyses, they have assessed how visuals highlight certain elements through the choice of colours, spatial scale, time horizon, and imagination while marginalising others. In addition, visual framing of climate model results does not only shape how climate change vulnerabilities and consequences are perceived and understood, but they also impact how decisions are taken on governance and adaptation as a result (e.g., Morseletto, 2017; Spence & Pidgeon, 2010).

However, taking decisions on adaptation and governance is not an individual process. It involves a multitude of stakeholders of various disciplines (Turnhout et al., 2019). The consequences of extreme rainfall events concern fields such as water management, spatial planning, greenery, and urban development. Therefore, individual municipal actors cannot possess all required knowledge or awareness of all perspectives on water resources and spatial planning. Instead, every actor brings their own unique knowledge, expertise and background. Hence, it is essential for team effectiveness that information passing is well-coordinated through *interaction* (Cooke et al., 2013). This is also key in social learning theory, in which *"societal actors interact and develop alternative perspectives on a*

societal issue" (Bos et al., 2013, p.339). Through this interaction, individuals share perspectives on situations, problems or tasks to be able to understand them and act accordingly (Gorman et al., 2006; Gorman & Cooke, 2011). Climate model results could accommodate the interaction between municipal actors, by reaching agreements, exchanging information or setting objectives (Eikelboom & Janssen, 2015).

1.3 Problem Statement

The magnitude and frequency of extreme rainfall events, and their potential negative impacts, are expected to increase in the future (KNMI, 2015b). Dealing with these extreme rainfall events has become increasingly challenging for municipal actors given the multitude of uncertainties. Adaptation tipping points, as well as climate model results and tools in general, have shown to create an imperative to act for municipal actors. They could accommodate interaction between municipal actors, by reaching agreements, exchanging information or setting objectives (Eikelboom & Janssen, 2015). However, a clarification of how a certain approach might offer decision support in a specific context is scarce (Kwakkel & Haasnoot, 2019), while the influence of the specific context on the extent to which a tool can be implemented and provide support to the interaction processes can be essential (Stanton & Roelich, 2021). Especially on the individual level, studies have given little consideration to the actors themselves and often assume they make rational choices (Stanton & Roelich, 2021).

This assumption of rational choices occurs despite studies showing that people tend to violate basic assumptions of rational decision-making under conditions of uncertainty (Kahneman & Tversky, 1979). When quantitative model simulations are simplified for municipal actors, information gets lost and might become unconsciously framed, leaving room for the non-rational interpretation of municipal actors. Unconsciously or not, visual framing can change the municipal actor's perception without altering the scientific information initially provided. Nevertheless, the implications of these visual framing effects of climate information are still relatively under-researched (e.g., Bell et al., 2001; Moser, 2010). Understanding these effects is important, as visually framed climate information does not only shape how climate change vulnerabilities and consequences are perceived and understood, but also how decisions are taken on governance and adaptation as a result (e.g., Morseletto, 2017; Spence & Pidgeon, 2010). Often, these decisions are not made by individuals, but by an interaction process between multiple actors of various disciplines. Through interaction with each other, actors interpret, learn and share perspectives on the issue to understand alternative perspectives and solutions to the issue. It is, therefore, important to understand how the visual framing of model results influences the interaction between municipal actors or municipal actors in general.

1.4 Case Study Description

To operationalise the influence of visually framed extreme rainfall information on interactions, the Huygenspark area, a neighbourhood in The Hague, together with the municipal actors within the *Municipality of The Hague* have been selected as a case study. This case study area and municipal actors provide a concrete example through which to explore the interaction and interpretation processes within the public sector, while The Hague is also characterised as one of the major urban areas in The Netherlands that is at risk of extreme rainfall events and its consequences (Krijger, 2018). In particular, it is expected that the neighbourhood of the *Huygenspark* will face severe issues during extreme rainfall events, as shown in Figure 1 (Gemeente Den Haag, n.d.-b). As can be seen, the Huygenspark is one of the areas with a large amount of water nuisance in The Hague, resulting in buildings at risk and inaccessibility of roads.

Figure 1: Inundation map of The Hague directly after a 70 mm/hour precipitation event, with the square area specifying the case study area of the Huygenspark. Top to bottom: water nuisance, inaccessibility of roads, the vulnerability of buildings. Adapted from Gemeente Den Haag (n.d.-b)

The Huygenspark is a typical urban neighbourhood located in the Stationsbuurt, a district within the city of The Hague. The area is enclosed by the central train tracks, the train station '*Den Haag Hollands Spoor*' and the surrounding canals, as shown in red in Figure 2. The neighbourhood owes its name to the Huijgenspark, a park located on the Northern side. Apart from this park and the Oranjeplein, the neighbourhood is known for its heavily paved public area and terraced brick houses, as shown in Figure 3. The buildings are mixed, but the largest portion is built between 1850 and 1910. The majority of these buildings exist for residential purposes, whereas the Stationsweg, as shown in Figure 2, is characterised by small grocery shops.

Besides the urban paved appearance, the Huygenspark is characterised by its multicultural young ambience. The neighbourhood has over 8.000 inhabitants of which approximately 76% are of immigrant

Figure 2: Graphical Overview of the Huygenspark

Figure 3: Pictures taken at the Huygenspark for visualisation purposes by the author

background. The neighbourhood has an average age of 32.4 years old, with a newly constructed Student Hotel attracting young students to the Huygenspark. The majority of its inhabitants has a low income, with 78% of the buildings being social housing, and with 2.445 households (out of 4.592) living below the EU low-income threshold and at risk of poverty. (Gemeente Den Haag, n.d.-c)

The Municipality of The Hague is responsible for making sure that the Huygenspark remains a safe and liveable neighbourhood within the city of The Hague. Currently, the Municipality of The Hague is lacking an adaptation strategy to tackle the future uncertainties of the Huygenspark in light of climate change and is therefore interested in new perspectives and tools to be able to do so (N. Al, personal communication, September 28, 2020; J. Amesz, personal communication, October 14, 2020). Adaptation tipping points could be an applicable tool to inform and decide on climate change adaptation for the Huygenspark, as it has recently been applied on neighbourhood and city scale (e.g. Butler et al., 2016; Zandvoort et al., 2019). As a result, the Huygenspark is an ideal case study area to assess whether and how the visual framing of extreme rainfall model results, of which adaptation tipping points is one of the ways to frame the issue, play a role in the interaction of municipal actors.

1.5 Research Objectives

This research aims to explore the influence of visually framed results from extreme rainfall models on the interaction between municipal actors. To support the main research aim, three sub-objectives are defined:

- To develop a theoretical framework that couples the conceptual fields of visual framing, individual interpretation and collective interaction to have an understanding of the context of adaptation tipping points;
- To assess an adaptation tipping point for extreme rainfall events in the Huygenspark;
- To determine how the visual framing of extreme rainfall model results influences the individual's interpretation and subsequently support interaction.

This understanding can contribute to validating the usage of visual models, such as the stress test, and the usage of adaptation tipping points, which will subsequently improve their practical applicability and understanding.

1.6 Research Questions

The problem description and research objectives lead to the following research question:

How does visual framing of extreme rainfall model results influence the interaction between municipal actors?

This main research question functions as the guiding principle throughout the study, which combines and integrates aspects of the master's degree in International Land and Water Management and the master's degree in Communication Design for Innovation. The main research question can be divided into four sub-questions, each supporting an essential part of the main research question:

1. *What are the issues in interaction surrounding climate change adaptation that model results might overcome within the Municipality of The Hague?*

The first sub-question aims to scope the research to have an initial understanding of the organisational structure, working methods, and issues in interaction that model results might overcome within the Municipality of The Hague.

2. *How does the concept of adaptation tipping points relate to visual framing theory within the field of cognitive sciences?*

The second sub-question forms the theoretical basis of this study and consists of two phases. The first phase combines the concepts of adaptation tipping points, framing and cognitive biases. This is the theoretical starting point from which the four extreme rainfall model results have been framed and produced. Throughout the study, the theoretical interest has grown towards visual framing, interpretation and interaction. Consequently, the second theoretical phase builds the overall theoretical framework, providing an understanding of the context and interlinkages between visual framing, interpretation and interaction. The second phase, of which the result is the theoretical framework, answers the second sub-question and is used to interpret and reflect on the results in the discussion.

3. *What are the visual adaptation tipping points and chances for the Huygenspark for extreme rainfall events from the perspective of the Municipality of The Hague?*

The third sub-question assesses the adaptation tipping points and chances within the Huygenspark for extreme rainfall events. This gives a hydrological understanding of the socio-political objectives for extreme rainfall events in the Huygenspark, the limits of these objectives, and the chances the Municipality of The Hague has to stay within these limits. Together with the first phase of the theory, this results in the production of four visually framed model results.

4. *How do individual municipal actors interpret the usage of extreme rainfall model results on their interaction with colleagues?*

The final sub-question aims to address how the municipal actors foresee the influence of the four extreme rainfall model results, which are produced through the previous sub-questions, on the interaction with colleagues. Together with the reflection of the theoretical framework (theoretical phase two), and the interaction issues in the Municipality of The Hague, this will result in answering the main research question.

1.7 Reading Guide

The report is structured into nine chapters, as shown in Figure 4. Chapter 1, 2, 3 and 4 form the introductory basis of this study: the introduction, the theoretical framework, the methodology and case analysis of the Municipality of The Hague. This is followed by a production phase consisting of Chapters 5 and 6 in which the visually framed model results have been created. Chapter 7 is part of the next phase, the circulation phase, in which the municipal actors are confronted by the extreme rainfall model results. Chapter 8 and 9 form the closing part of this research, consisting of the discussion of the results and the conclusion.

After the introduction (Chapter 1), Chapter 2 studies the relations between the main concepts and theories that are used throughout this study. This chapter answers sub-question two. Chapter 3 describes the research approach and used methods. Chapter 4 gives a more in-depth description of the Municipality of The Hague by answering sub-question one. Chapter 5 presents the identification of the two negative framed extreme rainfall model results, including the assessment of adaptation tipping points. Chapter 6 describes the identification of the two gain-framed extreme rainfall model results. The combination of Chapter 5 and 6 answers sub-question three. Chapter 7 states the results of the semi-

structured interviews in which the municipal actors have been confronted by the four extreme rainfall model results. This answers sub-question four. Chapter 8 discusses how the results of the study relate to previous studies, the methodological shortcomings, implications of the results, and future recommendations. Chapter 9 concludes the study by bridging the sub-questions and answering the main research question.

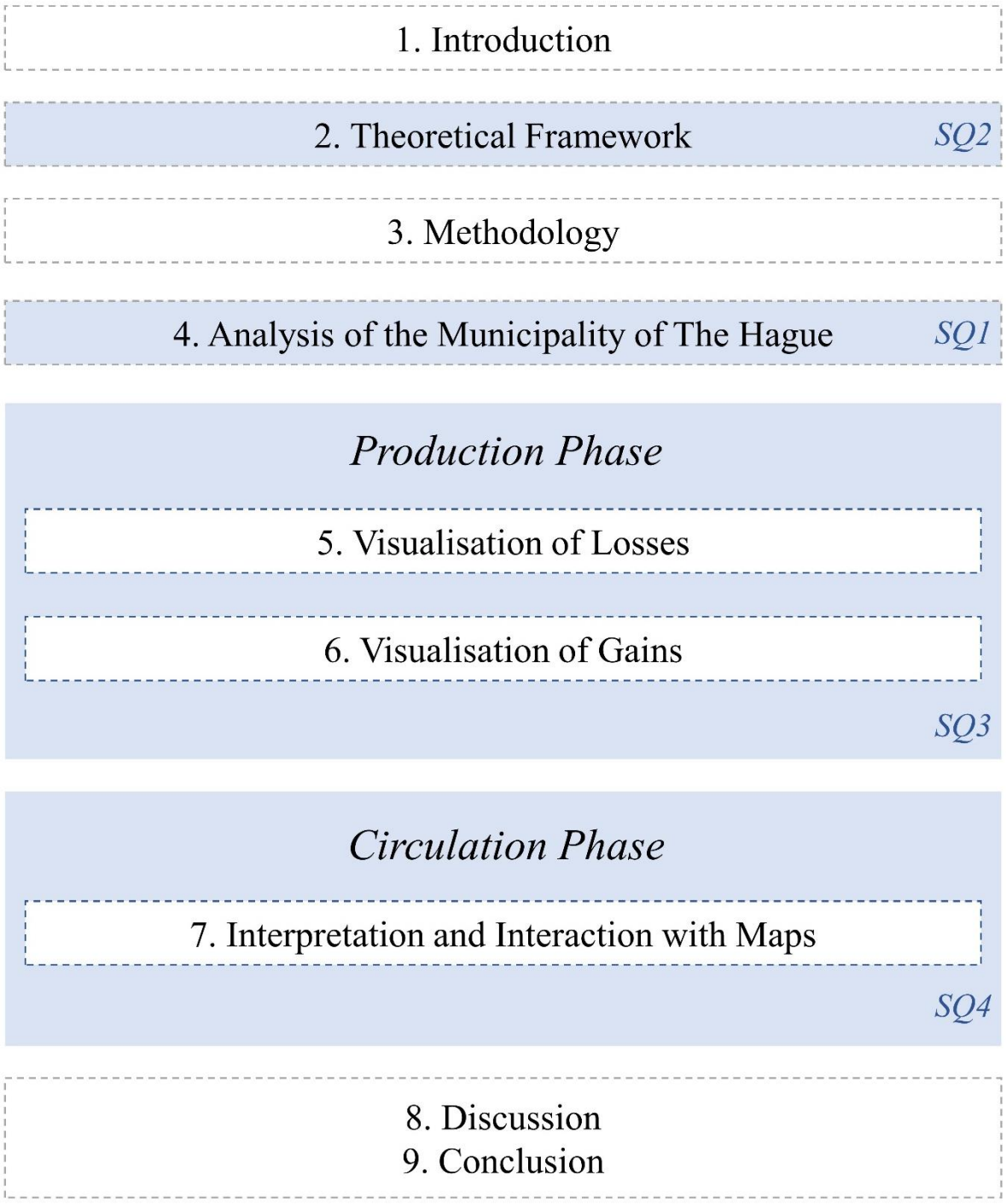

Figure 4: Reading Guide

2

Theoretical Framework

This chapter describes the main concepts and theories that are used throughout this study, which provide support for answering the before-mentioned research questions. The assessment of theories and concepts consists of two phases. Phase One is the theoretical starting point of this study. This phase starts from the concept of adaptation tipping points as a way of framing the issue. For the purpose of this study, this was extended to the concepts of cognitive biases and framing. This has resulted in the theoretical perspective to frame extreme rainfall model results: *the four quadrants of framing* (Section 2.1). After having a clearer understanding of the direction of the study, this quadrant has been extended to theories and concepts in cognitive sciences in Phase Two (Section 2.2). This expansion connects the four quadrants of framing to an individual's interpretation and the collective context of team interaction. In Phase Two, a theoretical framework has been created, relating the four quadrants of framing to the concepts of visual framing, mental models, and interactive team cognition (Section 2.3). This framework shows the key concepts, constructs and their relations that are used to reflect and structure the results in the discussion (Chapter 8). This theoretical framework also answers the second sub-question of this research: "*How does the concept of adaptation tipping points relate to visual framing theory within the field of cognitive sciences?*"

2.1 Phase One: Coupling Adaptation Tipping Points, Framing, and Cognitive Biases

The focus of adaptation tipping points on climatic impacts in terms of potential system failure instead of climatic impacts is a way to frame the issue. *Framing* is a process in which certain elements are highlighted, in this case, the consequences assumed relevant to municipal actors. Frames "*help simplify complex issues by lending greater weight to certain considerations and arguments over others, translating why an issue might be a problem, who or what might be responsible, and what should be done*" (Nisbet & Scheufele, 2009, p. 1770). Framing the issue causes individuals to interpret and process information differently, while the initial information remains equal. Framing, therefore, creates systematic errors in (rational) judgement when processing or interpreting information, referred to as *cognitive biases* (Tversky & Kahneman, 1974). Cognitive biases cause individuals to rely on mental shortcuts to solve problems and to make judgements on probability and risk quickly (Tversky & Kahneman, 1974).

Framing the issue through climate model visualisations and adaptation tipping points (unconsciously) plays into these cognitive biases and mental short-cuts by highlighting certain elements. While there is a multitude of frames that play into specific cognitive biases of individuals, De Boer et al. (2010) show that mainly two strategic contrasting frames have been applied to science-related communication:

1. *Goal orientation and focus*: whether the issue is approached from a promotion or prevention perspective.
2. *Perceptual distance:* whether the issue is addressed as either distal or proximal.

As these two frames are the main frames in science-related communication, they will be the starting point of this study. The first frame of either promotion or prevention by de Boer et al. (2010) is closely related to Prospect Theory in which the issue is framed as either a gain (promoting adaptation measures) or a loss (preventing negative impacts). Prospect Theory is a widely accepted framework for analysing decisions under uncertainty and originates in behavioural economics (Kahneman & Tversky, 1979). Because of this, Prospect Theory is discussed in-depth in Section 2.1.1. In addition, the second frame of perceptual distance is analysed through the Construal Level Theory, which discusses four domains of distance that influence the individual's mental image of the issue (Trope & Liberman, 2010). This theory is further explained in Section 2.1.2. Following these two contrasting frames, the adaptation tipping points concept has been conceptually extended to adaptation tipping points – opportunities as further explained in Section 2.1.3. These two contrasting frames, in relation to adaptation tipping points (- opportunities), together form the four quadrants of framing (Section 2.1.4).

2.1.1 Loss Aversion through Prospect Theory

Prospect theory (Kahneman & Tversky, 1979), and more specifically cumulative prospect theory (Tversky & Kahneman, 1992), is a theory explaining how people decide between alternatives (prospects) that involve risks and uncertainties. Prospect theory starts by contradicting the expected utility theory, a rational decision-making theory, by stating that the way people value an outcome is not always directly related to the monetary worth of that outcome. Instead, through numerous controlled experiments, Kahneman and Tversky (1979) show that people violate the most basic assumptions of rational decision-making. They show that people tend to highly overweigh losses compared to the equivalent gain, which they asses through a *value function.*

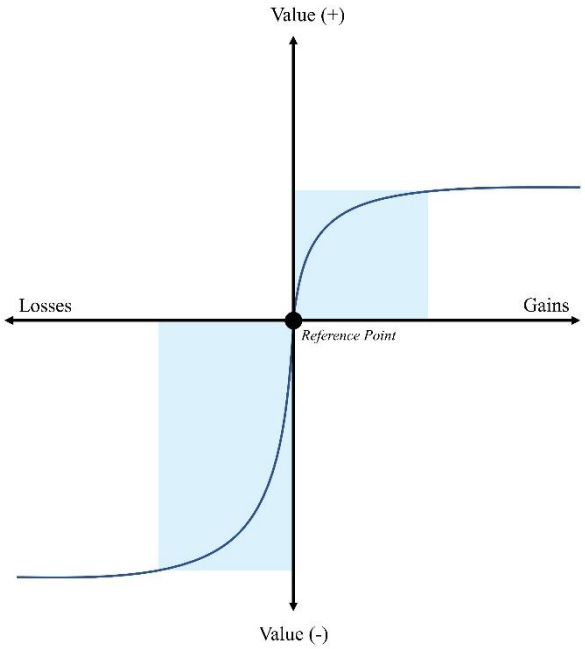

Figure 5: Value function showing a concave shape for gains and convex shape for losses, which demonstrates that people experience losses worse than the equivalent gain. Adapted from Kahneman and Tversky (1992)

The value function assesses the value that people describe to the issue or phenomena as either a gain or loss with respect to their *reference point*, as can be seen in Figure 5. An individual's reference point is psychologically defined, but can also be manipulated through external factors such as framing. As can be seen in the value function of Figure 5, the function is generally concave for gains and convex for losses, which shows that people tend to be risk-averse for gains, preferring the lower utility but with a higher certainty, and risk-seeking for losses, preferring the potential to avoid losses. This asymmetry in gains and losses is described as *loss aversion*, which demonstrates that people experience losses worse than the equivalent gain. Empirical evidence has even shown that the pain of losing is perceived as approximately twice as strong as the equivalent gain (Tversky & Kahneman, 1992). This shows that framing an outcome as a gain or loss relative to an individual's reference point can affect the individual's risk perception and subsequent choice for extreme rainfall events.

2.1.2 Psychological Distance through Construal Level Theory

Another theory describing an individual's perception relative to a reference point is the Construal Level Theory by Trope and Liberman (2010). The Construal Level Theory describes the direct relationship between the psychological distance from an object, person or event and the way people mentally represent it as either abstract or concrete. The central idea of Construal Level Theory is an increase in the psychological distance towards an object, event or person simultaneously increases the mental abstraction experienced. *Psychological distance* is the real or perceived distance between the object and the individual (Zwickle & Wilson, 2013). The psychological distance can be perceived and distinguished in four domains, as shown in Figure 6. Each of these four domains can be experienced as either high or low in level: (Trope & Liberman, 2010; Wang et al., 2021)

1. *Temporal distance:* how much time there is between the individual's reference time and the event, for example, right now (low) or the far future (high).
2. *Spatial distance:* how far away the event takes place from the reference point, for example in the neighbourhood you live in (low) compared to another continent (high).
3. *Social distance:* how distinct is the social object separated from the individual's self or the social group the individual belongs to, for example, the social distance experienced by someone similar to you such as friends (low) compared to the social distance when discussing a stranger from a distinct social group (high).
4. *Hypothetical distance:* the likelihood of the event happening, for example, rainfall to happen today (low) compared to experiencing climate change consequences (high).

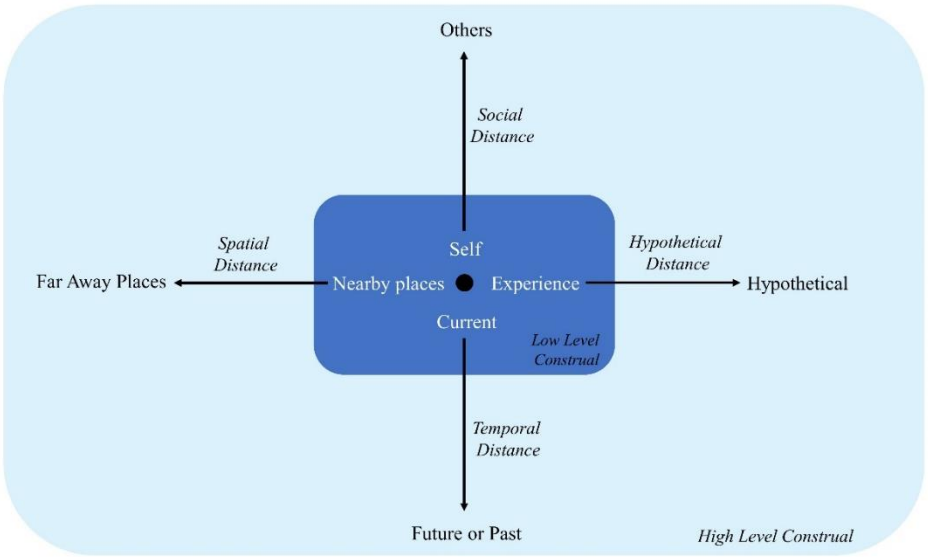

Figure 6: : Illustration of the four dimensions of psychological distance from the individual's reference point, adapted from Wang et al. 2011

Having a high or low level for each of these four types of psychological distance determines the way an individual thinks about a person, event or object in either abstract or concrete terms. This is also described as their *construal*, which is the way an individual perceives and understand the world around them. In Construal Level Theory, an individual's construal is classified into two levels:

1. *Low Level Construal:* The object, person or event is perceived as mentally near, which causes the individual to focus on concrete and specific features.
2. *High Level Construal:* The object, person or event is perceived as distant, which causes the individual to focus on abstract features and looking at the bigger picture.

Each of the four psychological distance levels can change through framing and shifts whether an individual mentally considers something as high or low level construal (abstract or concrete). However, these four dimensions are not linear and can influence each other. As an example, by changing the spatial distance you can also change the social distance, e.g. by focusing your message on how you would experience water damages in your own basement instead of focusing on a distant location with water nuisance. This way, the spatial distance is decreased from an unknown far-away location to your basement. This decrease in spatial distance also results in a shift in social distance from 'those people' to 'yourself'. These changes in distance cause the construal level to go from high to low construal. This shows that framing the issue as either distant or close in one or more of the psychological distance dimensions can cause an individual to consider the extreme rainfall issue or opportunity in concrete instead of abstract terms. (Trope & Liberman, 2010)

2.1.3 Adaptation Tipping Points – Opportunities

To expand the applicability of the concept of adaptation tipping points from a gain and loss perspective, the concept of adaptation tipping points – opportunities has been included. Koukoui et al. (2015) and Gersonius et al. (2012) introduce the concept of adaptation tipping points – opportunities by coupling adaptation tipping points to moments in time for which investment projects are already planned, such as sewer or infrastructure renewals, called 'opportunities moments'. The adaptation tipping point – opportunity methodology, therefore, starts with the same steps as the adaptation tipping points methodology by Kwadijk et al. (2010). After these steps, the methodology is merely extended by defining opportunities in urban renewal or maintenance cycles, as shown in Figure 7. By coupling these opportunity moments to the adaptation tipping points concept, it can be assessed whether it is possible to adapt to climate change in synergy with already existent infrastructural projects, as referred to as 'adaptation mainstreaming'. This way, the adaptation tipping point – opportunity methodology recognises that future changes are not solely a threat, but also an opportunity to improve the system. Therefore, to accommodate the gain and loss perspective, adaptation tipping point – opportunities can be conceptualised as the gain perspective of adaptation tipping points.

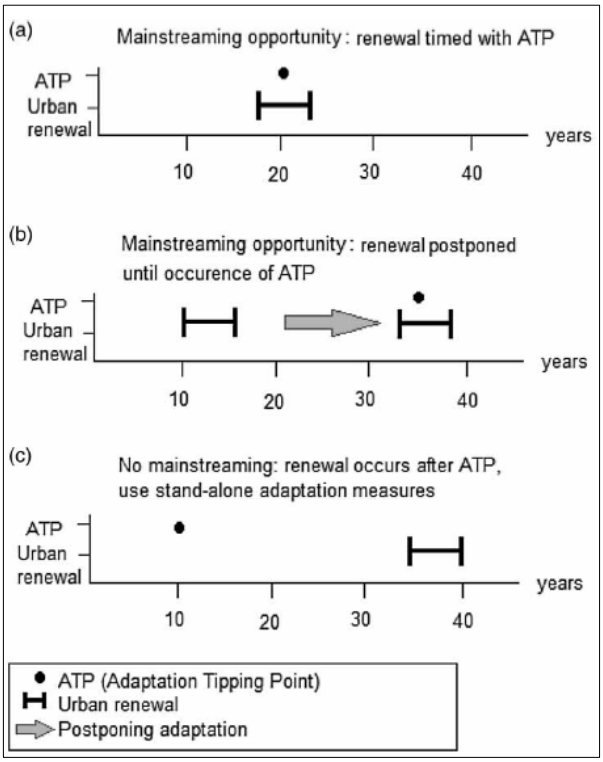

Figure 7: Mainstreaming opportunities: (a) urban renewal timed with ATP, (b) urban renewal postponed until ATP, (c) ATP occurs before urban renewal by Koukoui et al. (2015)

2.1.4 Four Quadrants of Framing

The two contrasting biases and respective frames of loss aversion (frame of gains or losses) and psychological distance (frame of distant or close) both relate to the individual's reference point. Because of this, these two contrasts can be seen as two axes, dividing the plane into four quadrants: distant loss, near loss, distant gain, and near gain, as shown in Figure 8. As adaptation tipping points show and emphasise the time when certain objectives *fail*, the author conceptualises the adaptation tipping points

as highlighting the negative aspects corresponding to a loss frame. Adaptation tipping points also intend to bring a distant temporal issue nearer by focusing on concrete socio-political objectives instead of the overall consequence of climate change. Adaptation tipping points are, therefore, conceptualised as a near loss frame. In contrast, adaptation tipping point – opportunities highlight the opportunities to improve the system through showing adaptation mainstreaming opportunities. Because of this, adaptation tipping points – opportunities are presumed to be equal to a near gain frame. These four quadrants, and their subsequent map division, have been the theoretical starting point for the production of the extreme rainfall model results in Chapters 5 and 6 for the loss and gain maps respectively.

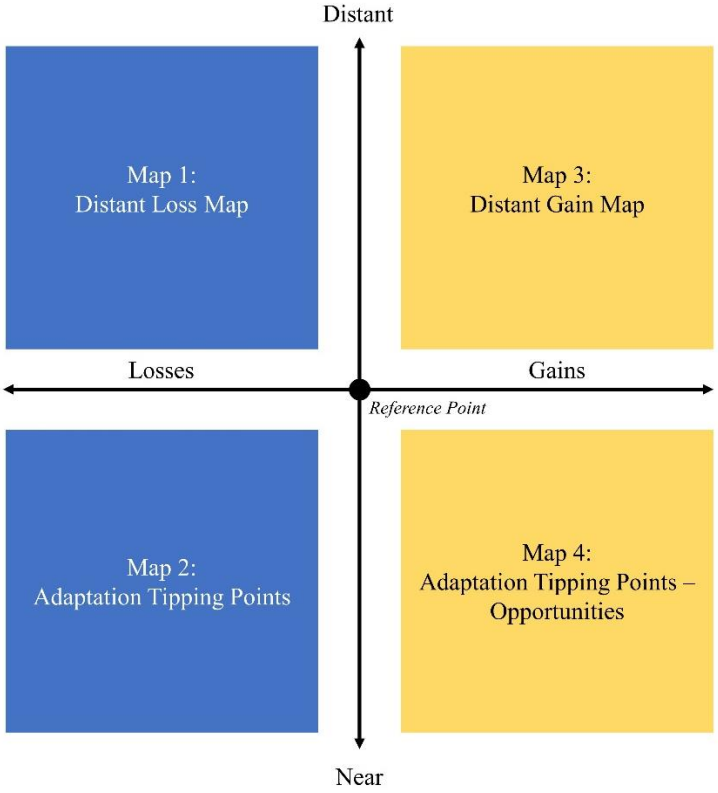

Figure 8: The theoretical starting point of this study relating the frames to adaptation tipping points (- opportunities). The outcome frame of either losses or gains is positioned on the x-axis, while the psychological distance frame of being distant or near is placed on the y-axis. These four quadrants are used to construct four visually framed extreme rainfall model results.

2.2 Phase Two: Coupling Framing, Interpretation and Interaction

To understand how these four visually framed model results influence an individual's understanding and subsequently their interaction with colleagues, the theoretical understanding is expanded to theories in cognitive sciences. This expansion starts from the concept of visual framing (Section 2.2.1) to have a clearer understanding of the different framing aspects of visuals. This is then expanded to the concept of mental models to provide a better understanding of how framing is interpreted by an individual (Section 2.2.2). As most interactions and decisions on climate change consequences are not taken solely by individuals, the theoretical framework is extended to teams by including the theory of Interactive Team Cognition (Section 2.2.3). These concepts and theories together create the Theoretical Framework (Section 2.3).

2.2.1 Visual Framing

In visual framing, a commonly used framework to assess visual framing is the four-tiered model by Rodriguez and Dimitrova (2011). Their framework distinguishes between four levels for analysing and identifying visual frames. It describes visuals as: (Rodriguez & Dimitrova, 2011)

1. *Denotative systems*: the concrete objects and elements shown within the imagery, for example, the image of a polar bear on an ice cap to depict the consequences of global warming.
2. *Stylistic-semiotic systems:* entails the stylistic components of the image and their social or cultural meaning, for example, certain colours or scales to depict an issue.
3. *Connotative systems:* includes the ideas or concepts behind these elements, for example highlighting certain elements in levels one and two can frame an issue as either physically distant or close.
4. *Ideological representation:* combines the symbols and stylistic features (level 1 and 2), together with the interpretation (level 3), into an overarching 'why' behind the imagery; the interests, ideas or voices heard. This level is difficult to assess, but it can be deduced from an interpretation of the previous levels. For example, the interest of showing climate change as a politicized and contested issue by showing close-up pictures (level 2).

These four levels of visual framing can each be analysed during a different stage within the communication and interaction process. In visual framing analysis, four stages during which meaning is conveyed and created by the image can be distinguished: the production of the image ('production'), the image itself ('visual image'), distribution of the image ('circulation') and a final stage during which the image meets its users or viewers ('audiencing') (Rose, 2007, 2016). These four stages do not happen linearly. Instead, it is a dynamic process in which the image is continuously adjusted, framed and reframed by users while travelling through different media.

To have a better understanding of the framing and reframing of environmental visualisations, van Beek et al. (2020) combine the frameworks by Rose (2007; 2016) and Rodriguez & Dimitrova (2011). Van Beek et al. (2020) contest Rose's (2007; 2016) use of four phases and propose merging the 'visual image'-stage with the 'production'-stage as well as the 'audiencing'- and 'circulation'-stage. They argue that this merging is necessary by stating that the image in itself cannot be detached from the production stage, as the image itself already involves the intentions of the producer during the production phase. Besides, they view the 'audiencing'-phase as inherently coupled to the circulation phase, as images reach a wide range of intended and unintended users with and without reframing.

Their framework, therefore, only distinguishes two stages: production and circulation, as shown in Figure 9. The production phase involves *how* the visualisation is produced and by *whom*. While the outcome of the production phase defines the stylistic features, objects and elements in the image (level 1 and 2), the characteristics of the producer influence the meaning behind the image (level 3 and 4) through their knowledge, expertise and perspective. After the production of the image, the image itself, and its features (level 1 and 2), may reach various unintended and intended actors. However, these actors are not 'passive'. During circulation, these actors interpret the image, make sense of it and possible use and give (new) meaning to the image (levels 3 and 4). They might keep the initial intention of the production phase, but they can also trigger different associations and new perspectives. Because of this, it matters *who* makes sense of the image, *why* and *how*. (van Beek et al., 2020)

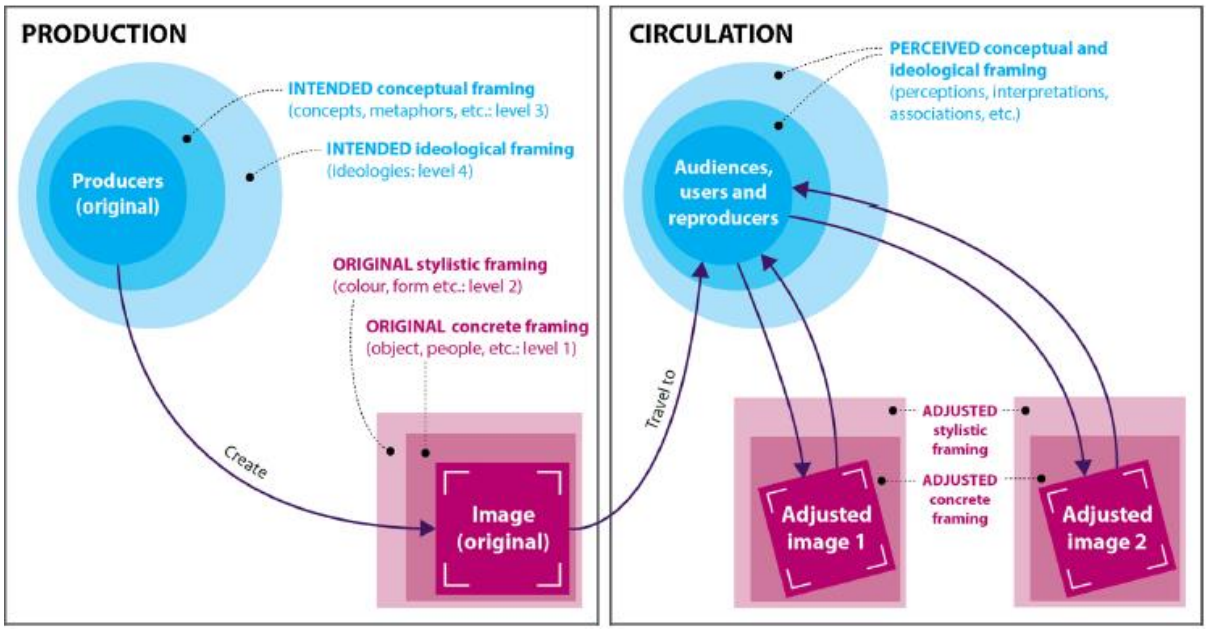

Figure 9: Schematic representation of the dynamic process of framing and reframing in the production and circulation phase by van Beek et al. (2020)

2.2.2 Mental Model

As described before, during the circulation phase, the audience needs to interpret and give meaning to the image. Even novel images are not experienced neutrally but undergo filtering through a knowledge structure of previous experiences, knowledge, cognitive biases and ideas. It is through these knowledge structures, the *mental model*, that people make sense and explain a situation that they encounter.

In cognitive science, a mental model is referred to as *"a psychological representation of a domain or situation that allows an individual to understand, to explain, and to predict future states"* (Liu & Dale, 2009, p. 224). This way, a mental model paints a picture of a certain situation, the elements of the situation and how these elements are connected. A mental model is not merely about a single piece of information, e.g. the name of a street, but also about the spatial relations between the elements, e.g. between the street and its neighbouring streets and landmarks. A framed picture of climate change consequences, therefore, can create relations to previous experiences, measures, and spatial implications (Liu & Dale, 2009). This way, an individual's mental model restricts the information flow by mainly accommodating the aspects that are present in the mental model in the person's mind. It can, therefore, be seen as a filter through which information, such as a visually-framed image, is processed (M. C. Nisbet & Mooney, 2007).

2.2.3 Interactive Team Cognition

While the perceived framing and interpretation are through an individual's mental model, most interaction and choices on climate change consequences are not taken solely by individuals. Instead, these decisions and interactions often take place in teams. A team refers to "*two or more people with diverse training and background knowledge that must be coordinated dynamically and adaptively to accomplish a task*" (Cooke et al., 2013, p. 256). In the theory of Interactive Team Cognition ((Cooke et al., 2013), team cognition is an activity, not a property, and emerges through *interaction*, often through explicit communication. This perspective on team cognition is in contrast with the Shared Cognition perspective, in which the sum of an individual's cognition together forms a shared team cognition. Instead, the Interactive Team Cognition theory recognises that the team cognition is larger than the sum

of components and that a team can achieve tasks beyond combined individual cognition through well-development interaction. As an illustrative example, great basketball players are often tall and muscular with long arms and legs. However, this does not mean that a team made up of persons with these right kinds of properties will be a successful basketball team. Rather, the interaction, how each member affects the other members, does. (Cooke et al., 2013)

Because of this, the theory of Interactive Team Cognition states that interaction is a better predictor than individual knowledge of team performance. In complex situations, such as climate change consequences, individual members cannot have all the knowledge or be aware of all perspectives on a situation. This is also not necessary. As every member brings his or her unique knowledge, expertise and background, it is essential for team effectiveness that information passing is well-coordinated. It is important to be able to share perspectives on situations, problems or tasks to be able to understand them and act accordingly (Gorman et al., 2006; Gorman & Cooke, 2011). In line with this, a (framed) visualisation of model results could accommodate the interaction between team members, by improving the information passing and understanding of knowledge and perspectives of other members.

Nevertheless, it is important to note that teams do not operate in a vacuum. Their environmental context composing of the organisational (higher) level and the individual (lower) level all influence how a team interacts and behaves. *Cross-level interactions* between individuals and the team have a simultaneous upward influence of the individual level towards the team level and a downward influence of the team level towards the individual level. Especially this cross-level interaction, together with the individual interaction with technology, in this study visual maps, is of interest for this study, as "*knowledge of lower level influences on the higher levels can help researchers explain the patterns of interaction that occur at the higher levels*" (Cooke et al., 2013, p. 271)

2.3 Conclusion

To reflect on the results, the theoretical understanding of the four quadrants of framing has been combined with the concepts of visual framing, mental models and interactive team cognition into a theoretical framework. In line with this, the following paragraph first summarises and combines the theoretical concepts and theories, after which an operationalisation table is provided (Table 1) to build the theoretical framework (Figure 10).

Framing, or more specifically visual framing, is a process of highlighting certain elements, such as the consequences relevant to municipal actors, while hiding others. The two contrasting frames and corresponding biases of interest for this study are loss aversion and psychological distance. The adaptation tipping points concept is conceptualised as a near loss frame, whereas the concept of adaptation tipping point – opportunities is conceptualised as a near gain frame. During visual framing, four levels can play a role: denotative systems, stylistic-semiotic systems, connotative systems and ideological representation. Individuals make sense of these framing levels through their mental model, which is the way people make sense of and explain a situation they encounter. This mental model is malleable and prone to errors due to cognitive biases. Cognitive biases are systematic errors in judgements that cause people to deviate from rational decision-making. Individuals, and their mental models, are part of teams situated within organisations. In this team, interaction is key to understand team performance.

Each of these components is operationalised in Table 1, which is the basis for the theoretical framework in Figure 10. This theoretical framework answers sub-question two: *"How does the concept of adaptation tipping points relate to visual framing theory within the field of cognitive sciences?"*

Table 1: Operationalisation table of the theories and concepts within the theoretical framework

Theory	Concept	Sub-Concept	Meaning
Visual Image			
Visual Framing	Four Levels of Visual Framing	Denotative Systems	The concrete objects and elements shown in the image.
		Stylistic-Semiotic Systems	The stylistic components of the image and their social or cultural meaning.
		Connotative Systems	The ideas or concepts behind the stylistic and denotive elements of the image.
		Ideological Representation	The overarching 'why' behind the image: the interests, ideas and voices highlighted.
	Two stages of visual communication	Production Phase	How the image is created by the producer.
		Circulation Phase	The interaction and travel of the image with the audience through interpretation and reframing.
Mental Model including Cognitive Biases			
Prospect Theory	Risk Perception	Loss Aversion	People experience losses worse than the equivalent gain.
		Reference Point	The individual's basis from which a situation or visualisation is evaluated, often the status quo.
Construal Level Theory	Four Domains of Psychological Distance	Temporal Distance	How much time is there between the individual's reference time and the event.
		Spatial Distance	How far away the event takes place from the reference point.
		Social Distance	How distinct is the social object separated from the individual's self or the social group the individual belongs to.
		Hypothetical Distance	The likelihood of the event happening.
	Level of Construals	High Level Construal	The object, person or event is perceived as distant, which causes the individual to focus on abstract features and looking at the bigger picture.
		Low Level Construal	The object, person or event is perceived as mentally near, which causes the individual to focus on concrete and specific features.
Team Perspective			
Interactive Team Cognition	Team Cognition	Within-Level Team Interaction	The interaction between the team members and technology, often through explicit communication flows and team coordination.
		Team Performance	The capacity of the team to reach certain output goals and the extent to which the expectations of its members, cost and time objectives are met.
	Contextual Environment	Cross-Level Interaction	The simultaneous upward level influence of lower levels and downward causation from higher levels.
		Individual Level	An individual interacting with technology, here the visual.
		Team Level	Two or more people with diverse training and background knowledge interact with each other and with technology.
		Organisation Level	A system of teams that interact between teams, people and technology.

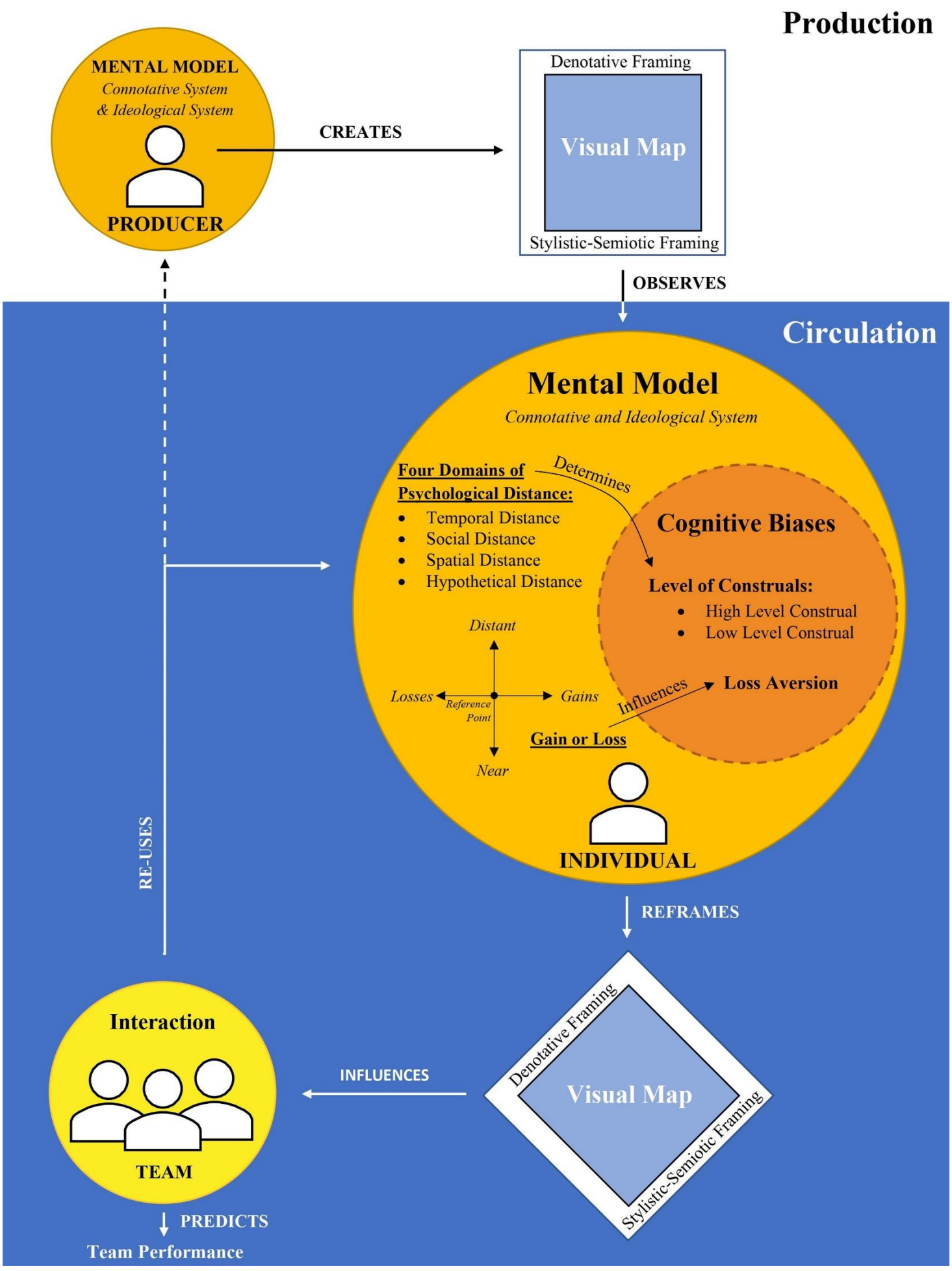

Figure 11: Theoretical framework showing the most important concepts and their relations, which has been used to interpret the results

3

Methodology

This research aims to address how the visual framing of extreme rainfall model results influences the interaction between municipal actors. This chapter describes how the research is set up and which methods are used to generate the necessary results. In line with this, this chapter starts by describing the research design (Section 3.1), which gives an overview of the methods used and relates them to the sub-questions and subsequent sub-chapters.

3.1 Research Design

There is currently a general idea that visual maps can improve or enhance interaction between municipal actors. Nevertheless, a clarification of whether this is the case in practice and how this might be happening is lacking. This lack of clarification is exacerbated by a limited amount of pre-research or prior information to the study. Because of this, this research can be classified as *exploratory*. Exploratory research explores the topic in-depth to create a better understanding of the issue. It is characterised by its flexibility, which makes it possible to adjust the research design when dealing with unforeseen discoveries. The goal of exploratory research is to clarify the issue, correlate concepts, and formulate concrete problems and recommendations for future research, which is in line with the result of this study. To reach this goal, this study makes use of a *case study*. The case study area for this research is the Huygenspark, a neighbourhood in The Hague. The case study actors of interest are the municipal actors within the Municipality of The Hague. The justification for the Huygenspark and the Municipality of The Hague can be found in Chapter 1.

Throughout this study, a range of quantitative and qualitative methods have been used following two parallels: (1) building a theoretical framework (theory) and (2) creating the visual maps for the water situation in the Huygenspark and confronting municipal actors with these maps (practice), as shown in Figure 12. The development of the theoretical framework consists of two phases, corresponding to the two different aims of the second sub-question as explained in the previous chapter. The methodological approach in practice consists of three consecutive phases: scoping, production of visual maps and circulation of visual maps. These three phases correspond to sub-question one, three and four respectively. These two parallels of theory and practice have been brought together in the discussion (Chapter 8), which reflects on the results in practice through the theoretical lens. The main research question is answered in the conclusion (Chapter 9).

In line with this, this chapter first describes the scoping phase (Section 3.2). This is followed by a description of the methods in the theory section that have been used to develop the theoretical framework, including its two distinct phases (Section 3.3). The next section describes the production of visual maps including the determination of adaptation tipping points (Section 3.4), and at last the circulation of visual maps (Section 3.5).

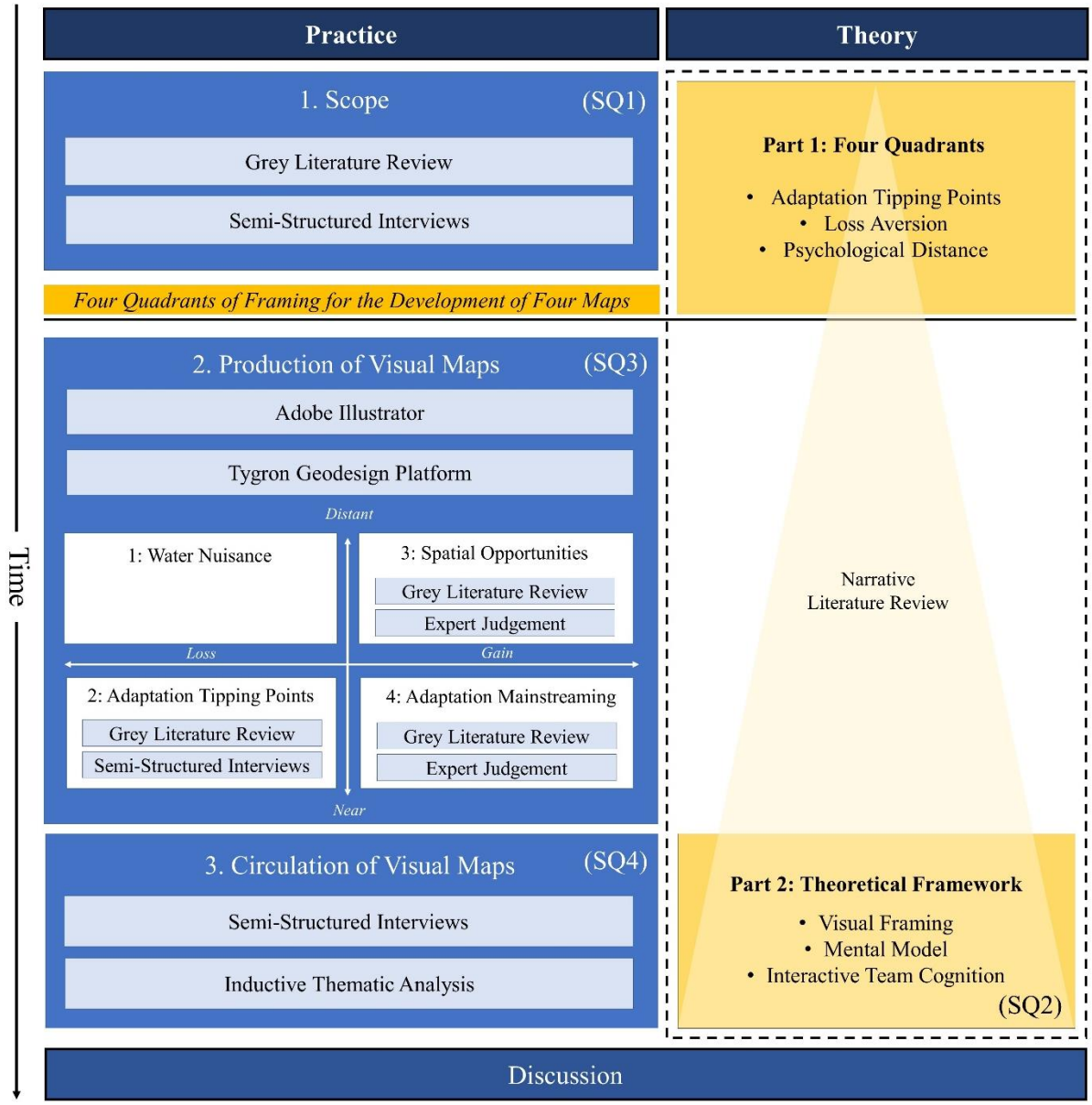

Figure 12: Overview of the research design including its methods with a distinction between theory and practice, which comes together in the Discussion

3.2 Scoping the Research

The study was conducted within the Municipality of The Hague. The municipality is a large organisation, consisting of over 6.800 employees, each with their own perspective and ways to interact with visuals and colleagues. Because of this large group, it was critical to first make a thorough analysis of the Municipality of The Hague following the two overarching aims:

1. To have an in-depth contextual understanding of their organisational structure, their working method(s) of tackling climate change adaptation, and their current visualisation of climate change consequences;
2. To determine the practical issue(s) in interaction that visual maps might overcome.

Following these two overarching aims, seven online *semi-structured interviews* with in total six employees have been conducted. One employee was interviewed twice due to time constraints in the

initial appointment. One main interview protocol functioned as the basis for all the conducted interviews. Before each interview, this protocol was adjusted towards the person's experience and job description, while still maintaining the same overarching aims. The interviews were conducted in Dutch and were held online via Microsoft Teams between a wide range of departments to give a broad insight into the Municipality of The Hague. An overview of the conducted interviews and the main interview protocol are provided in Appendix B.

The interviews were approximately 45 minutes to an hour and consisted of two components:

1. Understanding the decision-making and interaction processes within the Municipality of The Hague.
2. Determining the adaptation tipping points and climate issues within the Stationsbuurt (district), and more specifically the Huygenspark (neighbourhood).

The first component of the interview is in line with the two above-mentioned overarching aims. The second component was used as input for the development of adaptation tipping points, which will be explained in the Production Phase (Section 3.4). The semi-structured interviews, as shown in Appendix B, have resulted in a clear context description (Chapter 4), which is the answer to the first sub-question: *What are the issues in interaction surrounding climate change adaptation that model results might overcome within the Municipality of The Hague?* Besides, based on this description in Chapter 4, a decision was made on the targeted group of individuals to assess the interaction with visuals. This decision will be discussed in the Circulation Phase (Section 3.5).

Besides the seven semi-structured interviews, a *grey literature review*, e.g. policy documents and the web pages on the website of the Municipality of The Hague, has been conducted. The grey literature that has been reviewed was either referred to during the semi-structured interviews to substantiate their arguments or was relevant to the scope of climate change adaptation, extreme rainfall events, and the aims and objectives of the Municipality of The Hague to tackle these events. This grey literature review formed the substantiation of the context description in Chapter 4, while many documents also came of use during the production of the visual maps. During this phase, the documents assured that the description of the visual map corresponded to the perception of the interviewees.

3.3 Development of the Theoretical Framework

A *narrative literature review* has been carried out to establish the theoretical framework. The main search engines that were used to conduct the narrative literature review were the Wageningen University and Research library search engine, Google Scholar, and Scopus. The theoretical framework consists of two phases, each with a separate goal and search terms.

In Phase One, a narrative literature review has been conducted to get a better theoretical understanding of the visual framing components within environmental visualisations, such as adaptation tipping points. This consists of the two contrasting frames of losses and gains frames, from Prospect Theory, and the frame being psychological distant and near, based on Construal Level Theory. These two contrasting frames were the starting point of the study and were the basis for the construction of four visual maps. Here, the article by Kahneman and Tversky (1979) on Prospect Theory, as well as the article by Trope and Liberman (2010) on Construal Level Theory have been the starting point, after which the search has been extended to the search terms "cognitive biases" and "framing". The resulting four quadrants of framing can be found in Figure 9 in Chapter 2.

In Phase Two, after having a clearer understanding of the direction of the study, the narrative literature has been extended to provide an understanding of the context in which adaptation tipping points, and model results, are used for individuals and in a group. In line with this, this part consists of two aims:

1. To understand the *individual* context surrounding adaptation tipping points and visual model results in general. In this context, the user interprets the model results and gives meaning to them, which is the foundation for the collective interaction. This part consists of the four levels of visual framing and the concept of mental models.
2. To have insight into the *collective* context surrounding adaptation tipping points and visual model results in general. In this context, the user uses his or her interpretation of the model results for interaction. The extension towards the collective view is through the Interactive Team Cognition Theory.

In line with these two aims, the literature review has extended its search from the individual's cognitive biases to the image itself, by starting with the search terms "framing" AND "climate change". From there on, the *snowball method* has been applied, using the references or reference list of the main papers to identify additional papers. This resulted in a knowledge gap in visual framing and a closer look at the search terms "visual framing" AND "climate change", which was extended to "visual framing" AND "environmental" to have a larger scope. To understand how visual framing is coupled to the previous mentioned cognitive biases, the search was extended to "visual framing" AND "perception" after which a specific search followed on "mental model" related to the previous cognitive biases. Lastly, to extend the search from the individual to the team, the paper by Cooke et al. (2013) on Interactive Team Cognition was used as a key review document on shared and team cognition, from which the snowball method has been applied to find relevant papers.

From these findings, a theoretical framework has been built, as shown in Figure 11 in Chapter 2. This framework answers the second sub-question*: "How does the concept of adaptation tipping points relate to visual framing theory within the field of cognitive sciences?".* The theoretical framework has been used to reflect on the practical results and bridge theory and practice in the discussion (Chapter 8).

3.4 Production of Visually Framed Extreme Rainfall Model Results

The third phase in the methodological approach was to produce four visually framed extreme rainfall maps, in line with sub-question three: *What are the visual adaptation tipping points and chances for the Huygenspark for extreme rainfall events from the perspective of the Municipality of The Hague?* The creation of the visually framed maps was based on the two contrasting cognitive biases of presenting the issue as either a gain or loss and as distant or near, as described in Chapter 2. These four quadrants resulted in four distinct model results, hereafter called maps. To visualise these four maps, the visual consequences of extreme rainfall events on the Huygenspark are analysed through the *Tygron Geodesign Platform*. The Tygron Geodesign Platform is a cloud-based software package that allows users to generate a three-dimensional model of a specified project area. A full description of the model setup can be found in Appendix A. The model simulations made in the Tygron Geodesign Platform were altered towards their visual quadrant frame in *Adobe Illustrator*. A full description of how the four individual maps are made and altered in Adobe Illustrator can be found in Chapters 5 and 6 for the loss and gain maps respectively. The following section will only go into detail about the adaptation tipping points approach, which has been used to create the near loss map (Map 2).

3.4.1 Adaptation Tipping Points

To assess the adaptation tipping points, the three steps approach by Kwadijk et al. (2012) has been followed, as shown in Figure 13.

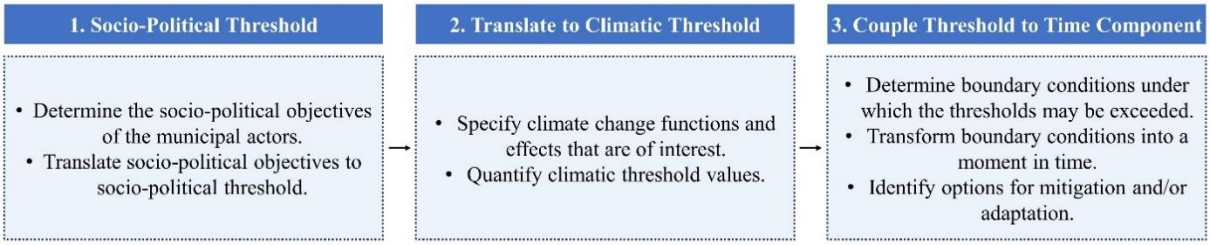

Figure 13: Adaptation Tipping Points approach, adapted from Kwadijk et al. (2010) and Koukoui et al. (2015)

The first step in the adaptation tipping points approach defines the socio-political objectives and translates these into a socio-political threshold. This step aims to construct a comprehensive picture of the perceived issue, adaptation objectives, and current situation. This comprehensive picture is developed through the seven previous-mentioned semi-structured interviews, discussed in Section 3.3, which also functioned to determine the socio-political objectives for the adaptation tipping points. For this part of the interview, the semi-structured interviews all had the same four overarching goals:

1. To assess the perceived current state of the Stationsbuurt including the Huygenspark;
2. To determine their perceived most pressing issue for the future of the neighbourhood;
3. To assess the subsequent amount of impact that is deemed unacceptable, which correlates to the adaptation objective(s);
4. To identify potential measures for these issues (pre-work for opportunities).

However, during the interviews, it became clear that the municipality does not have neighbourhood specific objectives for extreme rainfall events. Instead, for extreme rainfall events, the municipality agrees upon the nation- and municipal-wide objectives that for each smaller scale project have to be translated to the relevant scale, e.g. to the scale of the Huygenspark. To underline these objectives, the interviewees referred to multiple policy documents, plans and laws. Because of this, this phase was substantiated by a *grey literature review* of the mentioned policy documents. Based on the policy documents in the grey literature review and the semi-structured interviews, one socio-political objective is decided upon, as described in Chapter 5. In the second step, these socio-political objectives have to be translated into a quantifiable climatic threshold. The translation depends on the socio-political objective and the full explanation can be found in Chapter 5. After translating the socio-political thresholds, it has to be assessed under which climatic conditions these thresholds are reached and when these thresholds are reached (Werners et al., 2013). To be able to do this, different climate projections will be assessed on a geospatial scale. This has been done in the Tygron Geodesign Platform (Tygron Geodesign Platform, n.d.). The full description of the model set-up and the visualisation of adaptation tipping points can be found in Appendix A and Chapter 5 respectively.

3.5 Circulation of visually framed extreme rainfall maps

The fourth phase in the methodological framework was to assess how individual municipal actors interpret the influence of extreme rainfall models on their interaction with colleagues. Due to the focus on cross-level interactions between the individual perception and the team level, and the Covid-19 restrictions, the choice was made to conduct individual *semi-structured interviews*. These interviews have been analysed through an *inductive thematic analysis*.

3.5.1 Semi-structured interviews

Fourteen online semi-structured interviews of approximately an hour have been conducted in Dutch within the Municipality of The Hague. One main interview protocol functioned as the basis for all the conducted interviews, which can be found in Appendix C. This interview protocol followed four goals, corresponding to the four distinct phases in the interview protocol. The four goals together give insight into the personal factors that could influence their perception, their cognitive processes and way of looking at the maps, their perceived usage and influence of maps in their daily work and their foreseen influence of maps on the interaction with colleagues. The following four paragraphs will discuss each goal separately.

The first goal of the interviews was to determine the personal factors that might influence their perspective and interpretation of the extreme rainfall models. In line with this goal, the interview started with questions according to six dependent variables: proximity to the area, recent experience with extreme rainfall events or consequences, type of job, expertise (knowledge in the field of water management), viewpoint on extreme rainfall events (whether considered an issue) and familiarity with graph format.

The second goal of the interviews was to gain insight into the cognitive processes of the interviewee to understand their initial interpretation of the maps without an estimation or reference to other colleagues. Their initial reaction or interpretation has been assessed by asking the interviewees to think aloud when observing the map(s). The think-aloud protocol provided an understanding of what the map represented and meant to the interviewee, which mental images or consequences they correlated to the map, which aspects of the map they noticed and how they read the map and/or text. This way, asking interviewees to think aloud gave insight into the participant's cognitive processes. In addition, follow-up questions made sure to understand why they mentioned these aspects.

The third goal of the interviews was to couple their understanding of the map(s) to their daily individual working tasks and decisions. This gave insight into how the interviewee perceived the map(s) to help him or her during work and in which way they would use the map. This also assured that interviewees pictured and translated the maps to their work, which made the step towards questions related to their colleagues easier.

The fourth goal of the interviews was to determine the foreseen influence of maps on the interaction with colleagues. This consists of the individual's estimation of how the maps could be used in interaction with colleagues and their expectation of how other colleagues would interpret and understand the maps. This part started by asking about the (group) situations during which the interviewee should account for extreme rainfall events, continued with questions on their estimation of how colleagues would interpret and understand the map during these situations. The phase ended with questions about which map(s) they would use during those interaction purposes, with which purpose and in which way.

During these interviews, the visual maps were all placed in a single pdf file. The pdf file started with an introduction map, followed by the four maps individually, and finalised by an overview of all maps, as shown in Appendix E. The order was equal for all interviewees and started from the issue maps to chance maps, becoming more abstract with each map: water nuisance (Map 1), adaptation tipping points (Map 2), spatial chances (Map 3), and adaptation mainstreaming opportunities (Map 4). This way, the maps started from a comfortably known map, similar to the Den Haag Klimaatatlas, and take a step towards an abstract discussion through each map. It is also the 'logical' order, as to understand the

chances you needed to be aware of the issues. The pdf file was shared in Microsoft Teams and only the interviewer had control of the movement between pages.

As described in Chapter 4, the Municipality of The Hague does not have a department focused on climate change adaptation and tackles it through adaptation mainstreaming. As a result, a range of actors can come across the maps. Due to the focus on practical projects and their usage of model results, four different types of jobs and subsequent employees have been identified that can make use of maps: public space designers or landscape architects, policy advisors or employees, technological (water-related) managers or employees and urban planners. To have a broad scope to explore the influence of visual maps on the interaction with municipal actors, it has been decided to conduct interviews with all four different types of job descriptions. Each employee has their area of expertise and scale of working on adaptation to extreme rainfall events. A full description of the 14 interviewees and the main interview protocol can be found in Appendix C.

3.5.2 Analysis of Semi-Structured Interviews

All interviews have been transcribed through *verbatim transcription.* During verbatim transcription, the interviews are typed out letter-by-letter as accurately and completely as possible. In this study, verbatim transcription is important, as the way something is said is key to understand the way something is meant and interpreted in line with their cognitive processes. The transcriptions of the fourteen interviews were documented in *ATLAS.ti 9.* ATLAS.ti is a computer programme that lets researchers analyse phenomena recorded in unstructured data, here recorded in text, through coding and labelling of quotations and showing relations between them.

After transcribing the interviews literally, an *inductive thematic analysis* has been performed to translate the qualitative data into desirable quantitative information and results. During a thematic analysis, the researcher closely examines the data to identify common themes. A theme is "*a pattern found in the information that at minimum describes and organizes the possible observations and at maximum interprets aspects of the phenomenon*" (Boyatzis, 1998, p. 4). To do this thematic analysis inductively means that the themes are solely determined based on the data instead of on theory or pre-existing knowledge. The inductive thematic analysis conducted here follows Boyatzis' three stages (Boyatzis, 1998): deciding on sampling and design issues, developing themes and codes, and validating and using the code.

In the first stage, the dependent variable(s) have to be decided upon and a compare-and-contrast process between these dependent variables should be conducted. As described in the first goal of the interview, the interviews consisted of six dependent variables. However, after conducting the interviews, the variables of 'proximity to the area' and 'recent experience with extreme rainfall events or consequences' were neglected. 'Proximity to the area' was cancelled out as all interviewees knew to some degree the area and had been there. Besides, the dependent variable of 'experience' was removed, as only one person experienced water damage recently and his/her experience directly influenced the dependent variable of 'viewpoint on extreme rainfall events'. This left the analysis of the interviews with four dependent variables, which were contrasted during the analysis. As can be seen in the results, the largest contrast in information was found between interviewees with different thematic expertise in the field. Because of this, this contrast was used as the basis for the thematic analysis.

In the second stage, after deciding on the dependent variable, the raw data of the largest contrasting interviews were analysed, labelled and coded: one interview with limited to no existing knowledge and one interview with specific thematic expertise. To start with the large contrast between interviewees, this assured that the themes and codes identified at both contrast ends were applicable for most, if not

all, interviewees in between these contrasts. The analysis, labelling and coding of these two interviews were first done separately. Afterwards, the large list of codes was compared and overarching themes became apparent. After this, the second round of both interview transcripts was conducted. This resulted in new codes, while also deleting non-significant ones. The final codes were either data-driven or map-specific. Map-specific labels were always overlapping with the inductive label and corresponded to the map the interviewee was talking about, e.g. “Map 1”.

In the third stage, the code had to be validated and used. This was first done by labelling an interview in the middle of these two contrasts (an interviewee with general thematic knowledge). This resulted in no new codes or themes. Because of this, the coding was followed for all interview transcripts. After coding all interviews, the raw information linked to each code was compared to see whether it was similar and whether appropriate and reliable information was labelled. After validation of the code, all interviews underwent coding for a second time. The resulting codes and themes can be found in Appendix D.

After the labelling, coding and categorising according to a theme, the labels of themes were coupled in ATLAS.ti to the labels of the maps (which is the previous mentioned map-specific label). This resulted in two analyses. First, the maps were independently assessed in terms of interpretation, stylistic features and interaction, e.g. everything with Map 1-code and coupled codes. Besides, the themes were also compared to distinctive themes, which resulted in comparison and relations between interpretation, interaction and stylistic features. This resulted in information and insights into the cognitive process and ways of looking and describing an individual map, the differences between the maps, as well as how the interviewee foresee using the map in interaction. These insights together answer the fourth sub-question: “*How do individual municipal actors interpret the usage of extreme rainfall model results on their interaction with colleagues?”*

4

Analysis of the Municipality of The Hague

Tackling extreme rainfall events within the Huygenspark is a process that requires the engagement of various departments within the Municipality of The Hague. To have a more in-depth understanding of the Municipality of The Hague and their working approach, seven interviews have been carried out with in total six employees. An overview of the conducted interviews is provided in Appendix B. One employee has been interviewed twice due to time constraints in the initial appointment. Based on these interviews, this chapter describes the organisational structure of the Municipality of The Hague (Section 4.1), their working method of tackling climate change adaptation through adaptation mainstreaming (Section 4.2), their problems in interaction which might be overcome with model results (Section 4.3), and their current visualisation of climate change consequences (Section 4.4). Together, this answers the first sub-question: *What are the issues in interaction surrounding climate change adaptation that model results might overcome within the Municipality of The Hague?*

4.1 Organisational Structure

The Municipality of The Hague is an administrative organisation of approximately 6.800 employees (Gemeente Den Haag, 2018). The organisational structure of the municipality is characterised by eight distinctive services, in Dutch referred to as *Diensten*, each responsible for a certain duty of care, e.g. urban management or public affairs (Gemeente Den Haag, 2020a). These services are separated into sub-services, which are then subdivided into departments and subsequently teams. Each team has a specific interest and expertise, for example, there is a team focused on maintaining the sewage system

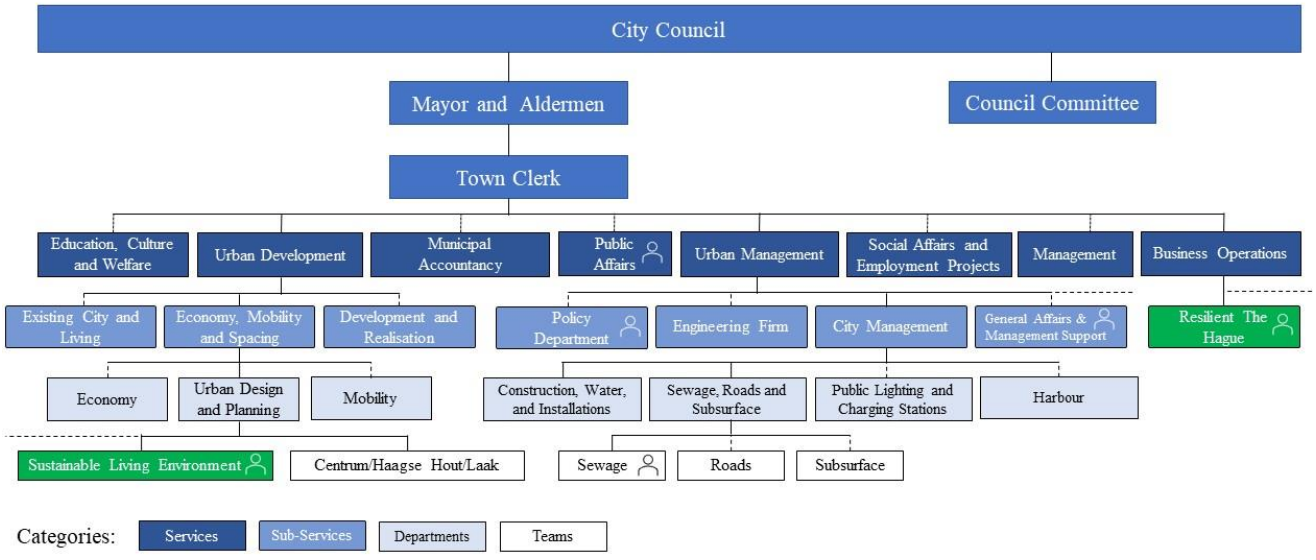

Figure 14: Organisational Overview of the Municipality of The Hague, only departments, services and teams shown that are either of interest for this study or have been interviewed. In green, the teams of interest for climate change adaptation.

(Team Sewage in Urban Management), while there is also a team of urban planners focused on the redevelopment of the City Centre district (Team Centrum/Haagse Hout/Laak in Urban Development). Each team supports and represents their own interest within their department and within the Municipality of The Hague. The organisational structure is shown in further detail in Figure 14. The (sub-)services, departments and teams that are shown either contain an employee that has been interviewed (characterised by the person-symbol) or are of interest for this case study on extreme rainfall events.

As can be seen in Figure 14, there is not a specific department or team within the Municipality of The Hague that solely focuses on tackling climate change consequences. While the employees of the Sustainable Living Environment Team (shown in green in Figure 14) increasingly concentrate on climate change adaptation as an integral part of liveability and sustainability, the Municipality of The Hague mainly aims to construct an integral approach. In this integral approach, they aim to mainstream considering and acting on climate change consequences throughout the municipality during every project, decision and policy chain. To reach this goal, two teams take on the leading role in creating awareness of climate change consequences and stimulating the integral approach within the Municipality of The Hague: the Ambassador's Team and the Resilient The Hague Team.

The Ambassador's Team is a transcending team that consists of three employees of two departmental teams that work on the Climate Adaptation-file ('*Dossier Klimaatadaptatie*'). As it is a transcending file that binds these three employees together, the Ambassador's Team is not an official team in the organisational structure and is not shown in Figure 14. Within the Ambassador's Team, two employees are from the Team Sustainable Living Environment within the Service Urban Development ('*Team Duurzame Ontwikkeling in Dienst Stedelijke Ontwikkeling*'), shown in green, together with an employee from the policy department of the Service Urban Management ('*Dienst Stadsbheer*'), which has been interviewed (shown with the person-icon). Their team has been involved in the development of the *Den Haag Klimaatatlas*, The Hague's visualisation of climate consequence. They have also developed an 'internal roadshow', which is an internal document explaining to colleagues how to mainstream adaptation in everyday work. They are currently working on the approval of a 'signpost'-document, *Wegwijzer,* with guidelines to initiate action for climate change adaptation and sustainability.

In addition, the Resilient The Hague Team is a team within Resilient The Hague Service, as shown in green in Figure 14. The team came into existence after joining the 100 Resilient Cities network in 2016. The Resilient The Hague Team is responsible for creating The Hague's Resilience Strategy and is currently working on achieving those objectives (Gemeente Den Haag & Resilient The Hague, 2019). Within the Resilience Strategy, adapting to climate change is one of the visions to build a resilient urban city. The Resilient The Hague Team overarches the executive Services, e.g. urban management and urban development. They try to achieve their overarching municipal-wide visions on climate change adaptation by mainly trying to stimulate awareness within the Services on future (climate) risks and potentials in everyday work through resilience training.

4.2 Adaptation Mainstreaming in Projects

The integral working approach that these two teams aim to achieve is adaptation mainstreaming ('*werk met werk maken*' or '*meekoppelkansen*'). Adaptation mainstreaming is a way to tackle climate change consequences by implementing adaptation measures in synergy with already planned infrastructural projects, e.g. incorporating water robust measures during sewage or road repairs. This approach has also been discussed during the section on adaptation tipping points – opportunities in Chapter 2. Adaptation mainstreaming is preferred by all six interviewees as the risk of extreme rainfall events is

not deemed severe enough at the moment to act pro-actively. Currently, the Municipality only acts pro-actively if the inhabitants of that neighbourhood or street complain to the municipality, which interviewees state does not happen often. Besides, as there is not a climate department, this also means that there is not a sectoral budget for climate change consequences. Because of the low immediate risk and the limited budget, small steps towards the goal are deemed sufficient, e.g. implementing green spaces during road repair as opposed to pro-active water robust projects, which is exemplified by the following quote:

> *"It is organised in such a way that we really need to look at adaptation mainstreaming opportunities. There is not a department for it. There is also not an executive institution that has a budget to undertake something like this. So, when a street is being renovated, you have to look at who is renovating that street and how we would be able to implement climate adaptation" (Advisor of the Sustainability, District and Neighbourhoods Department within Public Affairs, personal communication, November 30, 2020)*

The main working method of the Municipality of The Hague, through which adaptation mainstreaming takes place, is project-based. A project can either be initiated top-down through a new policy, a new law, a board change, bottom-up through new internal or external knowledge, societal developments or problematic rainfall events. For each project, employees from various department teams are brought together to form a project team, as exemplified in Figure 15. This ensures that all interests are taken into account, as each employee represents their own department team's interest and their own budget. Depending on the type of project, specific predefined goals are set with clear deadlines and budgets. After specifying the direction and budget of the project, the internal engineering firm of the municipality (*'Ingenieursbureau Den Haag'*) can be required to turn these varying requirements into a design. This design will be executed by a contractor and, depending on the type of final construction, the construction will be maintained and managed by a certain team within the Urban Management Department (*'Stadsbeheer'*).

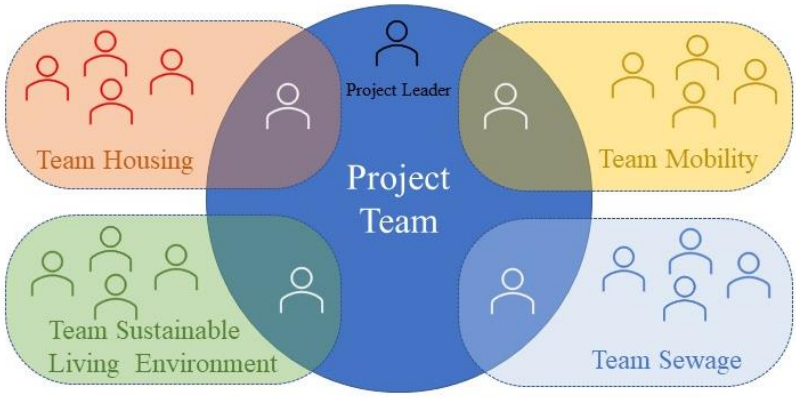

Figure 15: Illustration of the Municipality of The Hague's project-focused teams

4.3 Interaction Issue within the Municipality of The Hague

Due to the municipality's administrative system and organisational structure, separated into teams, departments and services, four out of six interviewees expressed their concern that the integrated approach required for climate change adaptation, and specifically extreme rainfall events, is challenging. Two main points of friction became apparent, which might be tackled by visual climate information: the focus of individuals on their own team's or department's interests instead of the

overarching vision required for climate change adaptation and the friction point between the required current action and costs in contrast to the future distant risks.

As every department team within the municipality has its own objectives, four out of six interviewees stated that most employees mainly consider their own budgets and interests, as exemplified by the following quotations:

> *"For a lot of projects, people really think within their own silo: "This is what I have to achieve", "These are my responsibilities", which is why they are less aware of the challenges that also at play and can influence their own project" (Chief Resilience Officer, personal communication, December 7, 2020).*

> *"It has to be clear from which department you are, but we have a municipal interest and often people act from their service or department interest. That is a safe group and people find that easier. Because if it becomes a bit more difficult, well it becomes more difficult, and it gets in the way of things" (Board Advisor of the Urban Management Board, personal communication, December 18, 2020)*

This focus on their department's own interest makes an overarching topic such as climate change challenging, as it requires employees to go beyond their specific department team's objectives. Employees have to 'do more' than their usual safe way of working to consider adapting to climate change. As there is not a specific department for climate change adaptation, it, therefore, might remain undiscussed or untackled in the projects. Besides, as the last quote signifies, this not only creates difficulties when interacting and discussing climate change consequences, but this difference also makes interacting in general difficult.

Besides, this department focus is also amplified by the sector-specific budgets of the Municipality of The Hague. As an administrative organisation, the main income of the municipality is through surcharges and taxes by its inhabitants, and through the municipal fund by the central government. This income is segregated into sectoral budgets between the various services and departments of the municipality. As climate change (adaptation) does not belong to a certain sector and subsequently sectoral budget, for every project or measurement that requires resources, it has to be justified why this additional budget is necessary. This, for example, also implies that budgets that are reserved for the sewage system or mobility transition cannot be broadened or spend on climate change initiatives. This keeps employees focused on their own budget restrictions, as exemplified by the following quotations:

> *"There are not many people that have the knowledge and the ability to see the complexities associated with heat stress, drought, and water. […] We are very object-oriented. The sewage team has knowledge about sewage. Interaction between them is difficult and making decisions between them is difficult. This is also because they all have different income sources" (Project Leader of the Sewage System, Roads and Subsurface Team, personal communication, November 19, 2020)*

> *"Our entire organisation is incredibly oriented around projects and budgets, and that is what we have approval for. This system is constructed quite like a military organisation, and that is also how we execute them. This is why our type of organisation also struggles with this subject" (Board Advisor of the Urban Management Board, personal communication, December 18, 2020)*

The focus on current (project) budgets is in friction with the potential future risks and the potential current actions and subsequent costs to avoid them later:

"These are often long-term challenges that you want to tackle now, but investing more money into it is complicated, because it is a long-term challenge which might not happen." [...] "In a municipal organisation, many people and politicians are more focused on the short-term, as they are often judged based on the short-term achievements " (Chief Resilience Officer, personal communication, December 7, 2020)

The main focus within the team's or department's objectives (mentioned by 4 out of 6 interviewees), amplified by the budget restrictions (mentioned by all interviewees) and the short-term focus (emphasised by the Chief Resilience Officer), is at cross-purpose with the integrated approach necessary for tackling extreme rainfall events.

4.4 Visual Maps

When asked about the risks of extreme rainfall events and how to decide whether to consider the integrated approach of mainstreaming adaptation, 5 out of 6 interviewees mentioned the stress test maps at the *Den Haag Klimaatatlas* as the first thing they look at. The stress test maps are visual representations of the climate risks in a certain area, as shown in Figure 16 and the before-mentioned Figure 1 for the Huygenspark (Chapter 1). The stress test shows the impacts of a 100-year return period rainfall event of 70 mm/hour, as well as the rain shower of 100 mm/hour. The website is publicly available and a wide variety of future issues, e.g. heat stress, land use, thermal energy, water damage are shown (Gemeente Den Haag, n.d.-a).

Figure 16: Webpage of the Den Haag Klimaatatlas, printscreen from Gemeente Den Haag (n.d.-a)

These maps are perceived as the way forward to climate adaptation: they visualise the risks and are able to couple these risks to current or planned projects in the municipality by zooming into certain areas. They are the first things employees look at, to decide whether they will mainstream adaptation or whether climate risks are an issue in the area. Because of this perceived crucial link in the approach to climate adaptation, it is interesting to see whether these types of maps indeed overcome the issues in the progress to climate adaptation.

4.5 Conclusion

The Municipality of The Hague is a large administrative organisation, separated into various services, departments and teams. Each team has their own specific objectives and their coupled budget. There is currently not a department or team specifically focussed on climate change adaptation. Their main working method is through projects, which bring multiple employees from various department teams together. The municipality aims for an integrated approach to tackle climate change consequences through adaptation mainstreaming. Adaptation mainstreaming (*'meekoppelen'* of *'werk met werk maken'*) is defined as taking measures during already planned projects. This corresponds to the approach mentioned in the adaptation tipping points – opportunities section in Chapter 2. Due to this required integral approach, the main issue in the interaction between team members within a project is the individualistic focus on the department team's objective amplified by the budget restrictions, instead of the overarching municipal climate goal. This answers the first sub-question: *What are the issues in interaction surrounding climate change adaptation that model results might overcome within the Municipality of The Hague?*

Production of Visual Maps

Based on the four quadrants of framing, as described in Chapter 2, four visual maps have been produced. To visualise these four maps, the Tygron Geodesign Platform has been applied. The Tygron Geodesign Platform is a cloud-based educational software package that allows users to generate a three-dimensional model of a specified 1 km^2 area. It makes use of (open) geodata as input for various hydrological, administrative and environmental equations and simulations. A full description of the model set-up and validation can be found in Appendix A. In line with this set-up and validation, Chapter 5 assesses and visualises the loss maps of water nuisance and adaptation tipping points for the Huygenspark. After visualising the two loss maps, Chapter 6 determines and visualises the gains maps. These chapters together answer sub-question three. Furthermore, the complete overview of the final model results of the production phase can be found in Annex E.

Chapter 5: Visualisation of Losses

Water Nuisance (Map 1) & Adaptation Tipping Points (Map 2)

Chapter 6: Visualisation of Gains

Spatial Opportunities (Map 3) & Adaptation Mainstreaming (Map 4)

5

Visualisation of Losses

Two maps from a loss perspective have been visualised: one near frame with a time component (the adaptation tipping points-map) and one distant frame without a time component. To come to these visualisations, this chapter starts by assessing the adaptation tipping point for extreme rainfall events from the perspective of the Municipality of The Hague. This assessment follows the three methodological steps: determine the socio-political objectives (Section 5.1), translate these objectives to a threshold (Section 5.2), and couple this threshold to a time component (Section 5.3). This results in a visual adaptation tipping points map (Section 5.4). This is followed by the creation of the water nuisance map (Section 5.5). The chapter is finalised by a conclusion describing the most important findings of this chapter (Section 5.6), which is answers the first half of sub-question three.

5.1 Socio-Political Objectives

The first step in the adaptation tipping points approach is to define the socio-political objectives of the Municipality of The Hague for extreme rainfall events. However, during four out of six interviews, it became clear that the municipality does not have neighbourhood specific objectives for extreme rainfall events. Instead, the municipality agrees upon the nation- and municipal-wide extreme rainfall objectives that for each smaller scale project has to be translated to the relevant scale, e.g. to the scale of the Huygenspark. For the municipal-wide objectives, the four interviewees either referred to recorded objectives in key policy documents or referred to the objectives discussed during their internal risk dialogues and workshops.

Because of this, this section first describes the responsibilities of the municipality concerning water management according to the environmental management law (Section 5.1.1), followed by the key documents that have been referred to during the interviews (Section 5.1.2). This is then followed by a short description of the objectives discussed in the internal risk dialogues (Section 5.1.3). According to these two different types of socio-political objectives, a decision on the analysed objective and the subsequent threshold(s) for the Municipality of The Hague have been made in the next section (Section 5.2).

5.1.1 Responsible for Water Management

On a national scale, the Law of Environmental Management, *Wet Milieubeheer*, obligates the Municipality of The Hague to maintain safe and efficient management and transport of water. The management of (urban) water is in collaboration with the Hoogheemraadschap van Delfland and the inhabitants and landowners of the Municipality of The Hague. Other important partners are Dunea, managing the drinking water, the Province of South-Holland and Rijkswaterstaat. The duty of care among the stakeholders can be distinguished into four categories: wastewater, rainwater, groundwater

and surface water. The responsibilities of the municipality for these four categories are legally documented in the *Wet milieubeheer (Article 3.5 and 3.6)*, and are shown graphically in Figure 17:

1. *Wastewater:* The Municipality of The Hague is responsible for the collection and transport of wastewater up to the main sewage pumping systems of the Hoogheemraadschap. Afterwards, the Hoogheemraadschap is responsible for the transport of water, including the sewage treatment plant and the purification of water.
2. *Rainwater:* In public space, the municipality is responsible for the collection and treatment of run-off water. On private property, the land or house owner is firstly responsible for the collection and treatment of water.
3. *Groundwater:* Underneath public space, the municipality is responsible for the shallow groundwater level, and legally needs to act if and when negative consequences are experienced. Underneath private property, the land or house owner is responsible for the shallow groundwater level. The Hoogheemraadschap is responsible for the water level of the surface water, which also influences the groundwater level. The deep groundwater (level) is the responsibility of the Province.
4. *Surface water:* The Hoogheemraadschap is responsible for the surface water quality and quantity. However, the municipality is the physical owner of the surface water, which is why the quality and quantity of the surface water is also seen as a goal of the municipality.

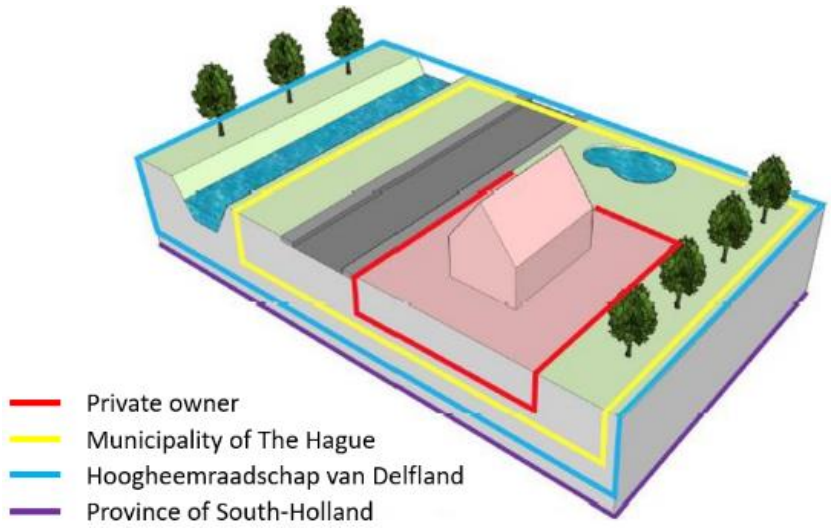

Figure 17: Graphical representation of the duties of care per stakeholder, adapted from Gemeente Terneuzen (2019)

5.1.2 Documented Rainfall Objectives

To achieve the legal obligation to manage and transport water safely, the Municipality of The Hague has various policy documents and reports that state and verify their ambitions and goals accordingly. Since the presented future scenarios of the KNMI in 2006 (KNMI, 2006), which show an increase in precipitation and extreme precipitation events, climate robustness and subsequently the response to extreme rainfall events have become an increasingly popular theme for municipal water management.

In 2012, the first initiative towards climate change adaptation and climate robustness in the Municipality of The Hague was reported through the *Uitvoeringsplan Klimaatbestendig Den Haag* (*Uitvoeringsplan: Klimaatbestendig Den Haag*, 2012). This twenty-page document highlights the expected future climate scenarios of the KNMI, their effects and consequences, and the general climate robust strategy objectives of the municipality. For extreme rainfall events, the objectives are to create more space and

retaining area for water through green spacing, to increase awareness about the negative effects of paved gardens and to increase climate change communication through water robust workshops.

Five years later, in 2017, the municipalities, waterboards, provinces, and the state publish a collective plan, which is called the Delta Plan on Spatial Adaptation, *Deltaplan Ruimtelijke Adaptatie* (Delta Programma, 2017). The Delta Plan emphasises the nation-wide exacerbating climate scenarios to fasten the development of spatial adaptation methods and to make the urban housing challenge more climate adaptive. In line with this, the Delta Plan requires the Netherlands to be water-resilient and climate-proof by 2050, including the municipality of The Hague. To achieve this, the Delta Plan consists of seven ambitions, with each their subsequent obligations (Ministerie van IenM & Ministerie van EZ, 2017). Currently, the Municipality of The Hague has achieved the first ambition by mapping out the climate change vulnerabilities through stress tests (Gemeente Den Haag, n.d.-b). The municipality is currently working on the second ambition to conduct risk dialogues with all relevant stakeholders. They have conducted their internal risk dialogues, which will be discussed in the next section, and are planning to organise the external dialogues with important stakeholders in 2021. After these dialogues, they will draw up an adaptation strategy.

Following the Delta Plan, the municipalities, water boards, organisations and housing organisations of South-Holland signed the Covenant Building Climate Adaptive South-Holland, *Convenant Klimaatadaptief Bouwen Zuid-Holland*, on the 4th of October 2018 (*Convenant Klimaatadaptief Bouwen in Zuid-Holland*, 2018). This agreement strives towards less water nuisance, more biodiversity, less heat stress, and less negative consequences from droughts and subsidence, compared to prior spatial development.

In 2019, the principles of the Convenant were translated into a Programme of Requirements, Programma van Eisen (*Programma van Eisen*, 2019). This programme states the minimal requirements against extreme rainfall events for urban areas and urban developments in the Netherlands. Due to the short duration and uncertainty of extreme rainfall events, STOWA (2018) has decided to restrict itself to a bandwidth with an upper and lower limit, which are based on the four KNMI'14 scenarios (KNMI, 2015a). Based on this, the stakeholders within the Convenant have decided to prepare for the upper scenario of 2050, which is shown in Table 2. For example, it shows that the one-hour precipitation event with a return period of 100 years is expected to increase by 21%. These factors are defined by the working group of the I&W, STOWA and RIONED, and help to standardise the objectives for the stress tests nationwide. Based on these factors, the requirements for theoretical extreme rainfall are: (*Programma van Eisen*, 2019)

1. A large part of the rainfall (50 mm) of a short heavy precipitation event (1/100 years, 70 mm/hour) has to be stored on private property with a delayed disposal;
2. No damage to buildings and facilities during an extreme precipitation event (1/250 years, 90 mm/hour), temporarily flooding on the street is allowed.

Table 2: The revised standard extreme precipitation events with a return period of 100, 250 and 1000 years for the current climate and the worst-case scenario in 2050 consistent with KNMI'14, translated from the Ministerie van Infrastructuur en Waterstaat, STOWA, & Stichting RIONED (2020)

Scale	Time	Return period current climate [years]	Precipitation current climate [mm]	Precipitation climate in 2050 [mm]	Factor
Local	1 hour	100 250	58 75	70 90	21% 20%
	2 hours	1000	128	155	21%

While this shows the extreme rainfall requirements for building damages and the required storage space of properties nationwide, the Municipal Sewage Plan, *Gemeentelijke Rioleringsplan*, reports the municipal requirements for standing water on the streets. The new *Integraal Gemeentelijk Rioleringsplan 2021-2025* (Gemeente Den Haag, 2020b), refers to the Handbook Public Space, *Handboek Openbare Ruimte* (*Handboek Openbare Ruimte*, 2020), which states the following norms:

1. Rain shower 08, *Bui 08*, precipitation event with 20 mm of rainfall within 60 minutes (return period of two years): no standing water on the street;
2. Rain shower 10, *Bui 10*, precipitation event with 36 mm of rainfall within 45 minutes (return period of ten years): maximum of 45 minutes of standing water on the street;
3. Climate shower, *Klimaatbui*, precipitation event with 70 mm of rainfall within 60 minutes (return period 100 years in 2050): no water nuisance or damages of properties and/or houses.

5.1.3 Rainfall Objectives in Dialogues and Workshops

While the objectives recorded in policy documents mainly focus on water damages to properties and/or houses and standing water on the streets, the Resilience City perspective (from The Hague's Resilience Strategy mentioned in Chapter 4) and the internal risk dialogues focused on a larger scale of disruption by emphasising the issue of critical infrastructure. Critical infrastructure is the infrastructure that is so vital for society that disruption would have long-lasting effects (de Jonge, 2021). In the CIrcle workshop (Deltares, 2019), a workshop held by Deltares with the most important stakeholders within the Municipality of The Hague to assess the risks for the Resilience Cities Network, some direct and indirect risks for critical infrastructure became apparent for extreme rainfall events:

1. Direct impacts to the accessibility of roads, which indirectly influences the access to emergency services and grocery stores;
2. Direct impacts to the electricity network by damaging the electrical power boxes, which may cause a cascading effect such as power outage.

The focus on critical infrastructure shifts the perspective from protecting all-around properties and/or houses to a more resilience-focused approach in which a minimum level of services is maintained. This focus on resilience acknowledges that it is difficult to plan for extreme rainfall events and that protecting all-round properties and houses, therefore, might be too expensive. Instead, by focusing on the resilience of critical infrastructure, this approach can be seen as more flexible and adaptable.

5.2 Socio-Political Threshold Value

Based on the documented and CIrcle workshop objectives, six socio-political objectives for extreme rainfall events can be summarised, as shown in Table 3.

Table 3: Socio-political objectives on extreme rainfall events in policy documents and during the CIrcle workshop

Documented Rainfall Objectives	CIrcle Workshop
1. Being able to store 50 mm of a 70 mm per hour rainfall event on private properties. 2. No damage to buildings and facilities during 90 mm per hour rainfall event. 3. No standing water on the streets during a 20 mm of rainfall within 60 minutes. 4. Maximum of 45 minutes of standing water on the street during a precipitation event with 36 mm of rainfall within 45 minutes.	1. Roads remain accessible for emergency services. 2. No damages to electrical power boxes.

For this study, it has been decided to visualise one adaptation tipping point. In line with this, first, it has been determined to focus on the critical infrastructure (Circle Workshop) objectives. This is because adaptability and flexibility lay at the core of the adaptation tipping points approach and the focus on critical infrastructure (when consequences become a serious risk to stakeholders) aligns with this adaptive and flexible perspective of adaptation tipping points. Second, it has been determined to focus on the direct impacts of the accessibility of the roads. This is because:

1. The socio-political objective focused on accessibility of roads aligns better with the municipality's responsibility (mentioned in the Law of Environmental Management) than the objective of no to limited damages to electrical power boxes;
2. The inaccessibility of roads is a serious follow-up consequence of the objective to have no or limited standing water on the streets, as documented in the Municipal Plan;
3. The inaccessibility of roads for emergency services was also mentioned by one of the six interviewees as a critical point in internal risk dialogues (of the Delta Programme).

Based on these three reasons, the deduced socio-political objective states:

"To maintain the accessibility of roads for cars and ambulances"

To quantify the accessibility of roads, the next step in the adaptation tipping points approach is to couple a threshold value to this consequence. In the Circle workshop, the following thresholds were determined to measure the inaccessibility of roads: (Deltares, 2019)

- Trams: 10 centimetres;
- Cars and ambulances: 30 centimetres;
- Fire trucks: 50 centimetres.

The master thesis by de Jonge (2021) also focused on critical infrastructure within the Municipality of The Hague and also based her study on the 30 centimetres threshold of Deltares (2019). As a result, this study also follows the threshold of 30 centimetres.

5.3 Time Component

In the Netherlands, time components are coupled to extreme rainfall events by analysing their return periods. As mentioned in the Documented Rainfall Objectives (Section 5.1.2), the objectives of the Municipal Sewage Plan are based on three different types of rain showers: rain shower 08, rain shower 10, and climate shower. These rain showers have a current return period of two and ten years, and a return period of 100 years in 2050, respectively. These three different types of rain showers, with each a different return period, could each result in an adaptation tipping point, as they each define their own precipitation event and subsequently have their own time component. Since the threshold for an adaptation tipping point requires the objective to be long-term and critical and the stress tests are also designed for a 100-year return period rainfall event, the adaptation tipping points were first defined around the 100-year return period rainfall event by stating the tipping point as: *"To maintain the accessibility of roads for cars and ambulances during a 100-year return period rainfall event of an hour".*

However, as short-duration extreme rainfall events in the Netherlands only have two scenarios (an upper and lower scenario as described in Section 5.1.2) and there is only a small percental change for extreme rainfall events, this would result in a relatively small range of precipitation events (STOWA, 2018). Currently, the precipitation event would be 58.5 mm/hour, increasing to 70 mm/hour for 2050 (21.3% increase) and 82.7 mm/hour for 2080 (41.4% increase), as shown visually in Figure 18.

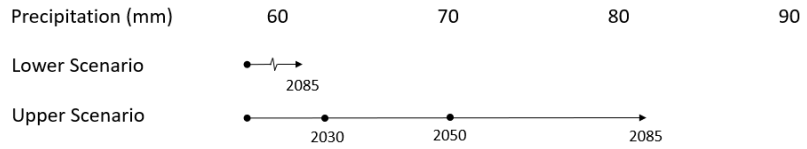

Figure 18: Visual Representation of 100-year return period of a rainfall event of an hour based on STOWA (2018)

Visually, it would therefore be more interesting to also include lower precipitation events, to have a larger range and to see whether this would already have an impact on the inaccessibility of roads. Because of this, it has been decided to choose precipitation events per step of 10 millimetres: 30, 40, 50, 60, 70 and 80 mm/hour. As the precipitation for short-duration extreme rainfall events of 10 minutes till 2 hours equally increase by 21.3% for the upper scenario of 2050, as shown in Table 2, this has resulted in Table 3 and visually Figure 19.

Table 4: The return period in years for the current climate and upper 2050 scenario for hourly rainfall events, based on the 21.3% increase following STOWA (2018)

Return Period [years]	Current [mm/hour]	Upper 2050 [mm/hour]
10	30-33: 31.5	38.2
20	35-39: 37	44.9
25	37-43: 40	48.5
50	44-52: 48	58.2
100	53-64: 58.5	71.0
200	62-79: 70.5	85.5
250	66-84: 75	91.0

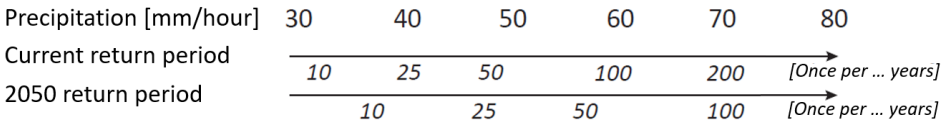

Figure 19: Visual Representation of current and upper-2050 return period per step of 10 millimetres

5.4 Adaptation Tipping Points Map

Based on the socio-political focus on the accessibility of roads, the subsequent threshold value of 30 centimetres, and the decision to take into account lower precipitation events (visually in Figure 19), the visual map for adaptation tipping points has been created. This visual map is shown in Figure 20. The map shows for each precipitation event in steps of 10 mm/hour the subsequent areas for which the threshold of 30 centimetres is reached. The layers are stacked on top of each other in Adobe Indesign. The substantiating text starts from the socio-political objective by emphasising the importance of the accessibility of roads for emergency services and explaining the 30 centimetres threshold. As can be seen in Figure 20, the Stationsweg (bright blue diagonally crossing the map) and the two tunnels reach the threshold relatively early. During a 40 mm/hour rainfall event, the Stationsweg and the tram tunnel are partly inaccessible, while for a rain shower of 30 mm/hour the Rijswijkseweg tunnel is already inaccessible.

Wegen niet begaanbaar voor veiligheidsdiensten

Mensenlevens zullen verloren gaan als veiligheidsdiensten, zoals brandweren en ambulances, niet meer door de straten kunnen. Dit gebeurt al bij 30 centimeter water op straat. Het niet kunnen bereiken van zieken en gewonden moet ten alle tijden worden voorkomen en wordt daarom gezien als kritiek omslagpunt in de Gemeente Den Haag.

De kaart geeft inzicht voor welke buien de wegen niet meer begaanbaar zijn voor veiligheidsdiensten.

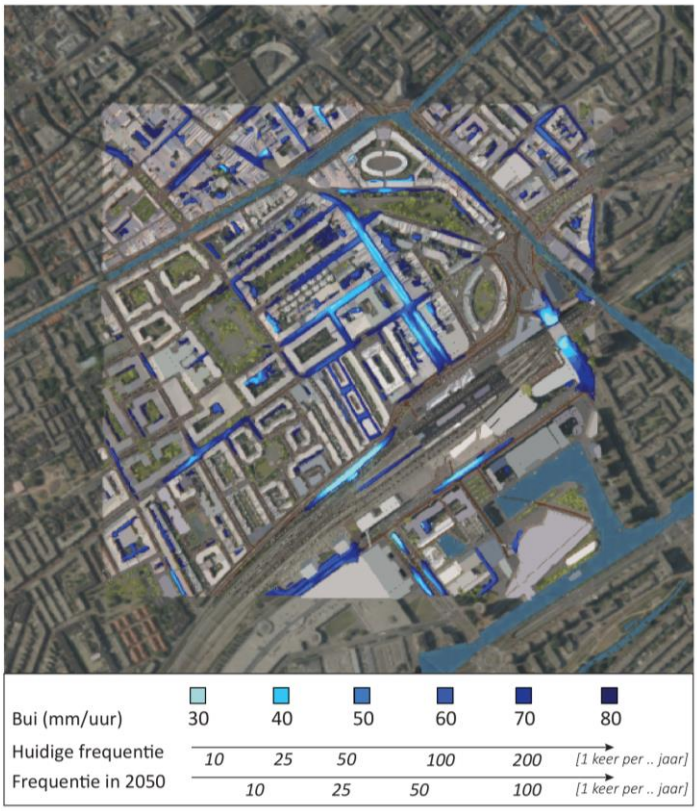

Figure 20: Adaptation Tipping Points Map (referred to as Map 2): 'Roads not accessible for emergency services'

Wateroverlast door klimaatbui

Extreme regenval veroorzaakt wateroverlast, gevaarlijke situaties en schade. Wateroverlast in het Huygenspark is bij extreme buien niet te voorkomen. De meeste van de huidige riolen zijn niet gebouwd om hevige regenval aan te kunnen. Het is daarom niet de vraag of, maar vooral waar de wateroverlast zal optreden, en welke gevolgen te verwachten zijn.

De onderstaande kaart geeft inzicht in de wateroverlast in het Huygenspark na een extreme bui van 70 millimeter.

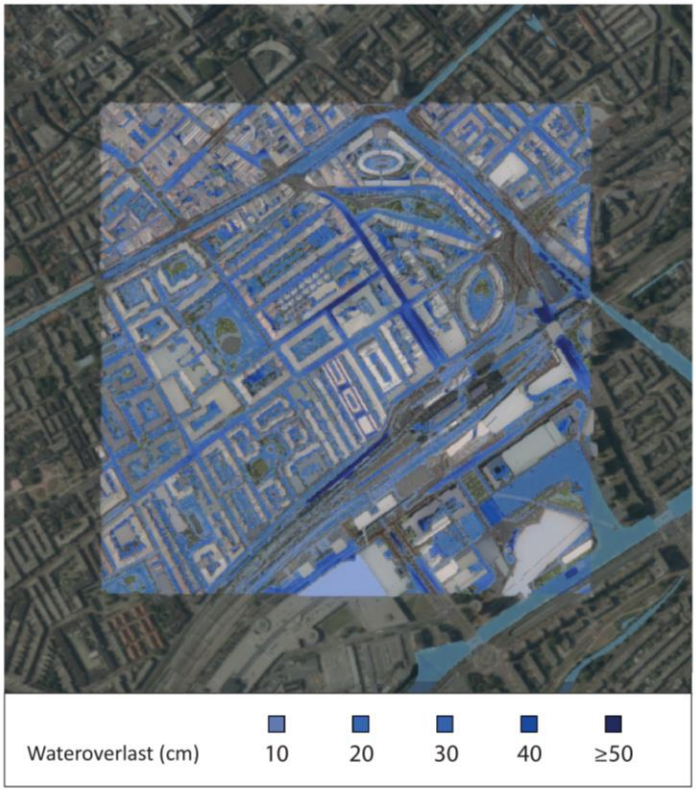

Figure 21: Water Nuisance Map (referred to as Map 1): 'Water Nuisance caused by Climate Rain Shower'

5.5 Water Nuisance Map

After determining the adaptation tipping points map, the distant loss map without a time component has been assessed. The distant map is in line with the *Den Haag Klimaatatlas* and merely shows the water nuisance in centimetres for one climate rainfall event ('*Klimaatbui*') of 70 millimetres per hour. The 70 millimetres of climate shower is according to the Municipal Plan objectives (Section 5.1.2). The water nuisance map is shown in Figure 21. The substantiating text of the map is based on the text of the stress tests at Den Haag Klimaatatlas (Gemeente Den Haag, n.d.-b) and starts by describing extreme rainfall events. This is in contrast with the adaptation tipping points map which starts by describing the socio-political objective of (in)accessibility. As can be seen, the Stationsweg, Rijswijksetunnel and the tunnel beneath the train tracks are again the areas with the largest water nuisance issues.

5.6 Conclusion

This chapter defines an adaptation tipping point for extreme rainfall events in the Huygenspark from the perspective of the Municipality of The Hague. This definition is based on the socio-political objectives recorded in policy documents, discussed in a CIrcle workshop organised by Deltares, and examined during the internal risk dialogues in line with the Delta Programme. Based on these objectives, the adaptation tipping point is determined to focus on critical infrastructure. Critical infrastructure is the infrastructure that is so vital for society that disruption would have long-lasting effects. The adaptation tipping point focuses on the critical transportation network and is defined as: *"To maintain the accessibility of roads for cars and ambulances"*. This tipping point corresponds to a climatic threshold of 30 centimetres of water on the streets. To couple a time component to this threshold, the return periods for the current situation and the upper scenario of 2050 of an hour rainfall are considered for precipitation events of 30 till 80 mm/hour, with respective steps of 10 millimetres. The precipitation in the upper scenario of 2050 is expected to increase by 21.3%. Based on this, the visual adaptation tipping points are shown in Figure 20. In contrast, the distant water nuisance map (Figure 21) shows the water nuisance in centimetres for the climate rainfall event ('*Klimaatbui*') of 70 millimetres per hour, in line with the Den Haag Klimaatatlas. In both maps, the Stationsweg, the Rijswijksetunnel and the tunnel beneath the train are bottlenecks.

6

Visualisation of Gains

After determining the two issue maps from a loss perspective, the other two visual maps should evoke a gain or chance perspective. This chapter describes the production of these two gain maps. This is done by first assessing the water management strategy of the Municipality of The Hague, followed by the translation of this strategy into two distinct types of chances in Section 6.1. In this section, the chance maps are further validated and discussed with an urban city planner working on the creation of climate maps from the municipality of Rotterdam (E. Arends, personal communication, March 17, 2021). This is followed by identifying the two final chance maps in Section 6.2 and Section 6.3 for Map 3 and Map 4 respectively. The chapter is finalised by concluding the most important findings in Section 6.4.

6.1 Water Management Principles and Chances

The Municipality of The Hague tackles their water management through a three-step strategy: to retain, to store, to drain (*'vasthouden, bergen, afvoeren'*) (Gemeente Den Haag, 2016), as shown graphically in Figure 22. This three-step strategy is recorded in the Water Policy 21st Century ('*Waterbeleid 21ste eeuw*') and National Administrative Agreement on Water ('*Nationaal Bestuursakkoord Water*'). The goal of this approach is to create and maintain a well-functioning water system that can sustain extreme rainfall events. In the first step, measurements have to assure that the rainfall is retained on the location itself, and if possible, infiltrated into the subsurface. For example, by applying green roofs, infiltration spots or wells, and water-passing pavement. The second step contains temporarily storing the water. This can be done on dry locations such as roofs or streets, but also in ponds or seasonal water storage. For example, by installing infiltration crates underneath streets, wadis or temporary water buffers. If the previous two steps do not sufficiently solve the issue, the excessive amount of water has to be drained with a respective delay from the location. For example, by open gutters or a separated sewage system. These three steps are also the preferred order of tackling water issues. This means that first and foremost the municipality should strive towards retaining the water by green spacing and infiltration areas.

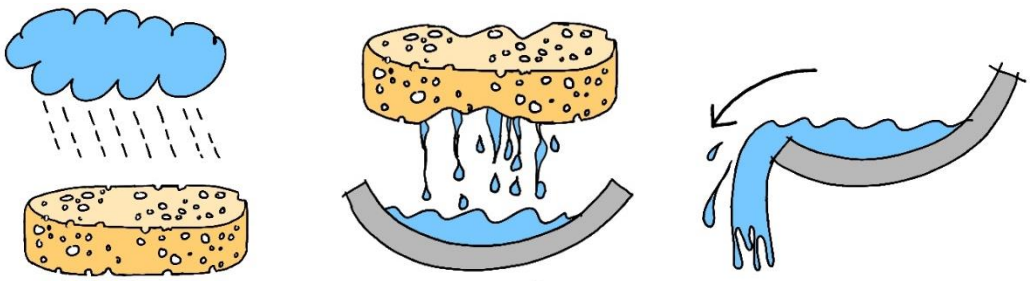

Figure 22: Illustration of the three-step-strategy of retaining, storing and draining water

Based on these three steps, measurements and chances are designed in respective order. For each step, two considerations that can result in potential chances have to be taken into account: (A. Hagen, personal communication, March 22, 2021)

1. Where is a spatial opportunity for measurements?
    a. *To retain*: space at private properties, e.g. large housing associations for green roofs.
    b. *To store:* space at public areas, e.g. parks or large open areas for wadi's or buffers.
    c. *To drain:* space underground, e.g. for a separated or improved sewage system.
2. Where is a project planned or currently going on so measurements can be taken in synergy?
    a. Adaptation mainstreaming focused on retaining, storing and/or draining.

In line with this two-sided division, two chance maps have been developed: one map showing the spatial chances without any time component and one showing the opportunities to couple actions to planned projects within a relatively near time period. This last map is in line with the adaptation tipping point – opportunities conceptualisation.

Besides, the necessity to highlight why something is a chance, instead of merely pointing out where work should be done to avoid water issues ('*opgavekaart in plaats van kansenkaart'*) also became apparent during the conversation with E. Arends, a city planner working on the creation of climate maps for the municipality of Rotterdam (E. Arends, personal communication, March 17, 2021). He advised to couple the chances to other themes that are of importance to the Municipality of The Hague. Because of this, each chance map is substantiated by text which is coupled to an overall ambition of the Municipality of The Hague. The text substantiating the spatial chance map is, therefore, coupled to the distant or vague sustainability ambitions as stated in the Central Innovation District. On the other hand, the text substantiating the adaptation mainstreaming chance map is coupled to the concrete municipal ambition to be climate robust in 2050, as stated in the Delta Programme.

6.2 Spatial Chances Map

As mentioned before, the spatial chances are either on private property, public space or underground. As the focus of the loss maps has been on public space or infrastructure through the emphasise on the accessibility of roads, the spatial chances will also focus on the public area. The determination of chances in the public area are based on a combination of the amount of open space available and the heightmap, which influences the run-off flow, as shown in Figure 23. As can be seen, the train tracks (bright red) are located relatively high, while the tunnels, as well as the two main streets (including the Stationsweg) with water nuisance, are also located relatively low. Because of this, the improvements of water nuisance are either at the high open-area locations from which the water flows towards the roads or the low locations themselves.

Figure 23: Height map of the Huygenspark with a colour scale from low (blue) to high (red) with an approximate range of +2.7 metres to -0.8 metres

In line with this, the first type of chances in public space is through large (high or medium-high located) open areas, as indicated in yellow in Figure 24. In the Huygenspark, as mentioned before, two large parks are present (the Huijgenspark and the

Oranjeplein), which are both large open areas that currently restore minimal water, as can be seen by the low amount of standing water in Figure 21. These large open areas could retain or store a higher amount of water, to elevate the issue at the lower located streets and are, therefore, indicated as chances by the yellow dotted line. Besides, after an orientation walk through the Huygenspark and analysing the heightmap, it also became apparent that the open area before the Rijswijkse tunnel could be improved in terms of infiltration and storage to improve the water nuisance issue at the tunnel, as shown heavily paved in Figure 24. Because of this, this area is also indicated as a chance by a yellow dotted line in Figure 24.

Besides the high-located large space open areas, the low locations which have large water nuisance issues, as shown in Figure 21, can also be improved in terms of water retention and storage. These locations are shown by white dotted lines in Figure 24. Especially the Hoefkade, which is called a "bathtub" (A. Hagen, personal communication, March 22, 2021) due to its low location and separation of the rest of the area, needs chances to be taken at the location itself. Based on the white and yellow coloured chances, and the coupled ambition of the Central Innovation District, the visual map of spatial chances is created, as shown in Figure 25.

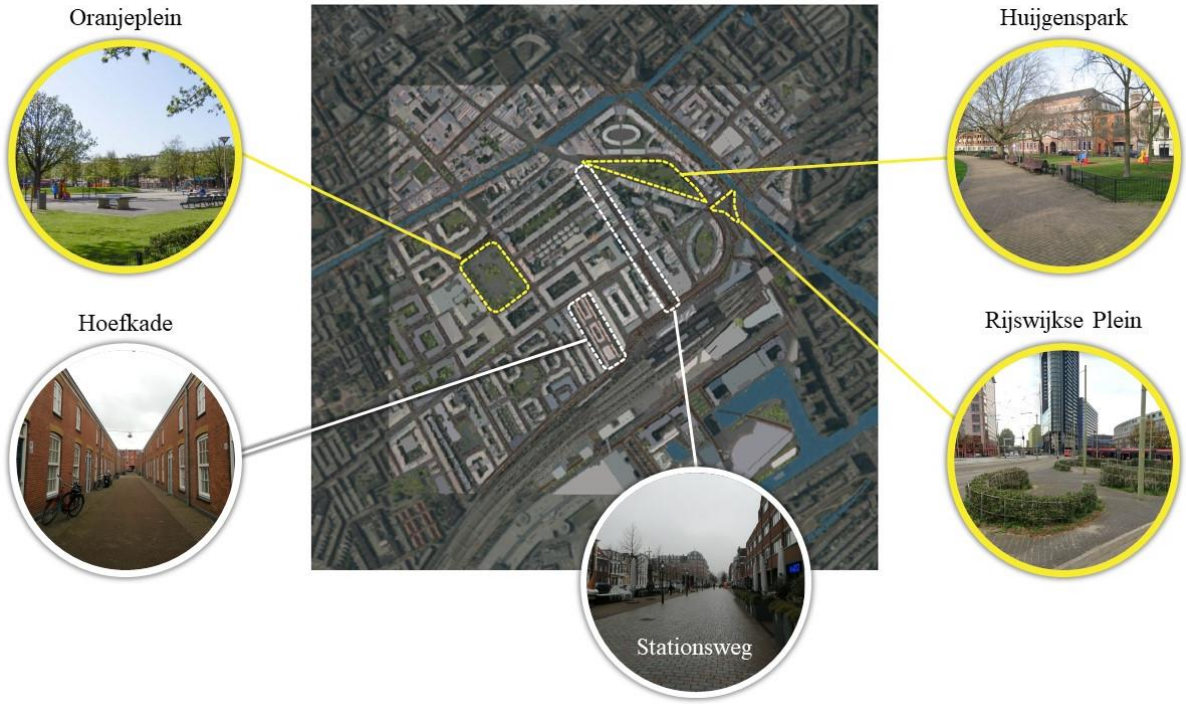

Figure 24: Pictures of specific chance locations and the location name per area indicated as chance. Either indicated in yellow for large open areas that are located high or medium-high or indicated in white for low-located areas with a high amount of pavement.

Kansen tot ontwikkelen waterrobuuste wijk

De ontwikkelingsvisie voor het Huygenspark, als onderdeel van het CID, is om over 20 jaar een duurzame leefomgeving te zijn. Door een hoge concentratie van private woningen en voorzieningen is een transitie in de openbare buitenruimte essentieel om dit te bereiken. Door een slimme combinatie van meer groen en het lokaal vasthouden en bergen van water wordt het Huygenspark niet alleen bestendig tegen extreme regenbuien, maar wordt het ook een buurt dat uitnodigt tot wandelen en ontmoet.

De onderstaande kaart geeft inzicht in waar de kansen liggen om het Huygenspark waterrobuust te maken.

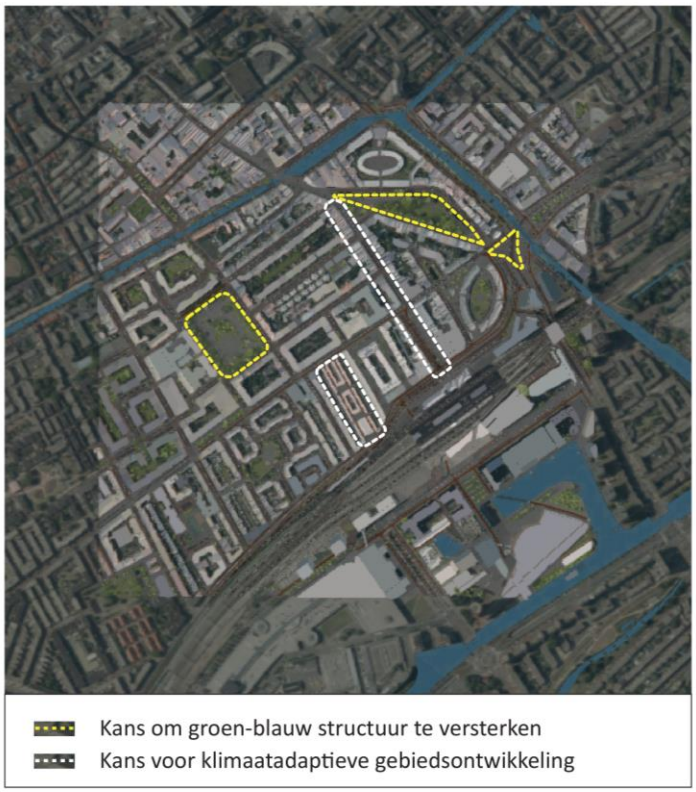

Figure 25: Spatial Opportunities Map (referred to as Map 3): Chances to develop a water robust neighbourhood

Herstructurering kansen voor een waterrobuuste wijk

Bij het renoveren of vernieuwen van het riool is het essentieel om ook de kansen te pakken om wateroverlast te voorkomen. Door meer groen en het lokaal vasthouden en bergen van water verbetert het watersysteem en zal wateroverlast en schade tijdens piekbuien worden voorkomen. Dit zal bijdragen aan de ambitie opgesteld in het Delta Programma om klimaatbestendig te zijn voor 2050.

De kaart geeft inzicht waar het riool op een termijn van 5 tot 15 jaar wordt aangepakt en waar de kansen liggen om het Huygenspark waterrobuust te maken.

Figure 26: Adaptation Mainstreaming Map (referred to as Map 4) showing the adaptation mainstreaming opportunities in the Huygenspark during sewage repair or renovation, this is in line with the adaptation tipping point – opportunities concept

6.3 Adaptation Mainstreaming Chances Map

To show the adaptation mainstreaming possibilities visually, a project manager at the Sewage Department (S. Chan, personal communication, March 19, 2021) was contacted by email to accurately have visual plans of the sewage system being replaced in the Huygenspark. As can be seen in Figure 27, there are a few sewage systems that are currently being replaced or renovated (green colour) and a few that are planned in 5 to 15 years. As the interest is on opportunities in the future, the map in the Tygron Model only contains the orange lines, as shown in Figure 26. The text substantiating the image of adaptation mainstreaming chances is in line with the three principles of water management and the ambition to be climate robust in 2050.

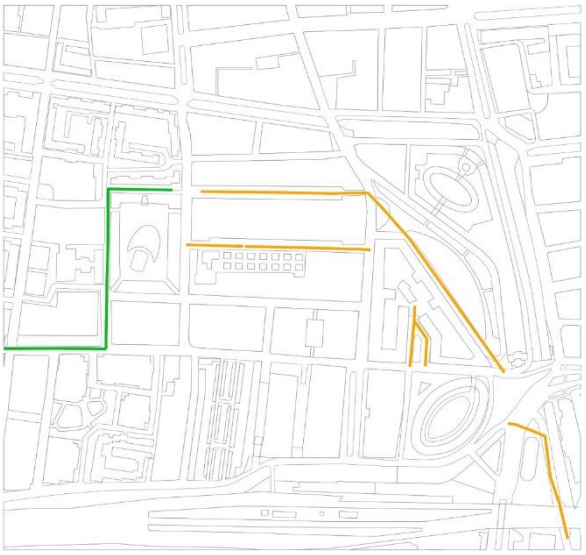

Figure 27: Map showing the sewage system replacement currently happening (green) and planned in the next 5 to 10 years (orange), provided by S. Chan (personal communication, March 19, 2021)

6.4 Conclusion

The Municipality of The Hague follows a three-step strategy for water management: to retain, store, and drain water. To execute these three steps, there should either be: (1) a spatial opportunity through the availability of space in public areas, the subsurface or on private property, or (2) an adaptation mainstreaming opportunity (‘opportunity moment’ in the adaptation tipping point – opportunity approach). This corresponds to Map 3 and Map 4 respectively. The high located large open areas are mainly in the two parks: the Huijgenspark and the Oranjeplein. The low-located areas, due to their ‘bathtub’ height map, need action taken on the location itself. Besides, the adaptation mainstreaming map shows the planned sewage repairs in the next 5 to 15 years, for which chances for extreme rainfall events can be coupled. These two chances answer the second half of sub-question three. Together with the conclusion of Chapter 5, this answers sub-question three: *“What are the visual adaptation tipping points and chances for the Huygenspark for extreme rainfall events from the perspective of the Municipality of The Hague?”*

Circulation of Visual Maps

After the production of four model results, the hereafter called visual maps enter the circulation phase, as discussed in the Theoretical Framework (Chapter 2). In this phase, municipal actors interact and interpret the visual maps. This interpretation and interaction is measured through 14 semi-structured interviews within the Municipality of The Hague. The results of these interviews will be listed in Chapter 7. This chapter answers the fourth and final sub-question: *"How do individual municipal actors interpret the influence of extreme rainfall models on their interaction with colleagues?"*

Chapter 7: Interpretation and Interaction with Maps

7

Interpretation and Interaction with Maps

This chapter describes the results of the 14 interviews that were conducted within the Municipality of The Hague. During the thematic analysis, as discussed in the Methodology Chapter, three overarching themes have been identified: interpretation, interaction and visual representation. Each of the themes will be discussed separately. The first section on interpretation describes the initial reaction of the interviewees on the four visual maps individually (Section 7.1). The section is structured in chronological order, starting from Map 1. This is followed by a section describing the potential interactions with other colleagues that the interviewees discussed based on their interpretation of the maps (Section 7.2). This section entails the tendency for action and the ability to interact or connect with (other) departments. The next section describes the last theme, which includes the comments made on the visual representation of each map individually (Section 7.3). This includes comments on colour, stylistic features and text. The last section concludes the three themes in the chapter (Section 7.4). These three themes together answer the fourth sub-question: "*How do individual municipal actors interpret the influence of extreme rainfall models on their interaction with colleagues?"*

Throughout the three identified themes, a distinction has been made based on their answer to the question: *'How familiar are you with the current situation and future consequences of extreme rainfall events in urban areas in the Netherlands?',* which was part of the introduction questions about their job description and responsibilities. Based on their job description and their answer to this question, three thematic expertise categories could be identified: specific thematic expert, climate change adaptation thematic expert, and non-thematic expert. First, the interviewees classified as specific thematic experts were either working in the water or sewage sector and had a specific background and knowledge on the technological measurements required, the hydrological system, and the sewage system of The Hague. Climate change adaptation thematic experts were specialised in climate change adaptation or sustainability. They do have a broad understanding of the consequences and effects of extreme rainfall events, but would need to contact a colleague for specific knowledge and technical expertise on measurements and certain areas. Lastly, non-thematic experts do have some degree of knowledge and understanding of extreme rainfall events through their responsibility as municipal actors. However, they would not deem themselves knowledgeable to make a decision on it and are not knowledgeable of the specifics. Based on this distinction, an overview of these three categories per interviewee can be found in Figure 28. Throughout the chapter, interviewees will be abbreviated with an 'S' for specific, 'C' for climate change adaption, and 'N' for non-thematic experts.

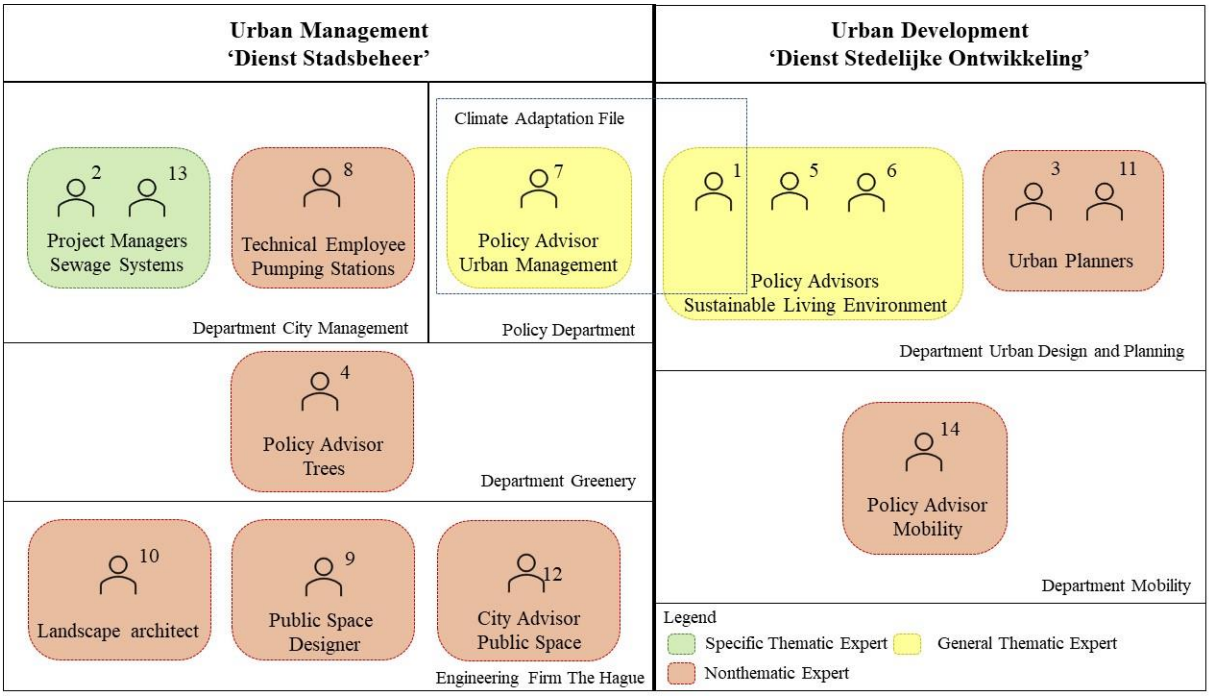

Figure 28: Overview of conducted interviews and their thematic expertise in the field of extreme rainfall events

7.1 Interpretation of Maps

The first overarching theme that has been identified is the 'interpretation of maps'. This theme entails the interviewee's personal understanding of the maps without an estimation or reference to other colleagues. Throughout this theme, interviewees discussed what the maps represents and means to them, and how they read them. This mostly includes their initial reaction to the maps when the interviewees were asked to think out loud. This reaction will be discussed for each map individually, in chronological order from Map 1 to Map 4.

The initial reaction on Map 1, as shown in Figure 29, shows a clear distinction between the interviewees that had specific thematic expertise and the interviewees that had either a climate change adaptation expertise or no thematic expertise. The five interviewees that have limited detailed knowledge (*Interviewee 1-C, 3-N, 6-C, 9-N, 10-N*) stated that while they could generally see whether or not there is water nuisance present in the area based on the gradient colour of blue, they were not able to decide whether water nuisance is an issue. When they read the number of centimetres in the legend they said that this information remained meaningless to them, as they could not determine and neither visualise the consequences of 10, 20 or more centimetres, as signified by the following quote: "*It [Map 1] is a kind of reality to which we relate, but which is still quite abstract, because you read water nuisance, but you do not really get a feeling for it*" (*Interviewee 3-N*). This response was also predicted by the two thematic experts within the Municipality of The Hague (*Interviewee 2-S and 13-S*) who, for example, stated that: *"For most people, this is not much of use. It says a lot to me, but I am a specialist in the matter. I know what it means" (Interviewee*

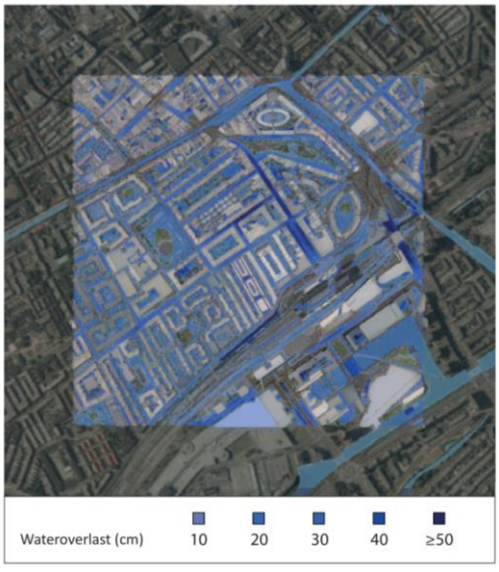

Figure 29: Small representation of Map 1 without the substantiating text.

2-S). As the two thematic experts both knew the area and the hydraulic infrastructure present, they could easily determine whether the number of centimetres meant that there was an issue that needed further analysis or not. In addition, in between the two thematic expertise extremes, the six interviewees (*Interviewee 5-C, 7-C, 8-N, 10-N, 12-N, 14-N*) with a general insight knowledge were able to outline certain consequences and issues of what these centimetres could entail. They all gave a quick summation of the possible consequences per amount of centimetres, e.g. inaccessibility for emergency services or water damages in basements, and then determined whether this might be an issue or not.

While for the first map it was difficult for nonthematic experts to understand and visualise what the image and centimetres meant, 9 out of 14 interviewees stated that the second map made the issue more concrete. By coupling extreme rainfall events to a direct consequence for the accessibility of emergency services, as shown in Figure 30, they stated that the issue became mentally visual: *"I have an image of the emergency services. I know what they are going to do over there and why. […] It makes it visual in my head what the issue exactly entails"* (*Interviewee 14-N*). It also created a more emotional reaction compared to Map 1, as the interviewees used words such as urgency, importance, and seriousness while describing the issue of water nuisance, which is exemplified by Interviewee 3: *"Number 2 is a really good translation of Map 1, which makes it really concrete for one specific component; what will happen and what does this mean for the accessibility. It thus clearly shows the urgency" (Interviewee 3-N)*. They also said that Map 2 clearer showed certain 'hotspots' or pain points that needed attention, such as the Stationsweg, while Map 1 had an abundance of blue over the entire map.

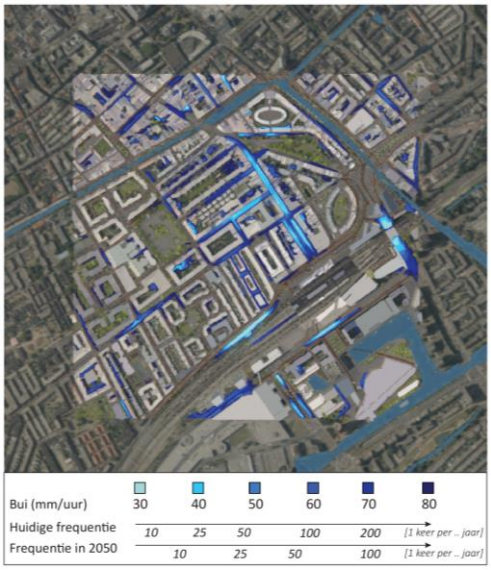

Figure 30: Small representation of Map 2 without the substantiating text.

However, not all actors interpreted the concrete translation of Map 2 compared to Map 1 positively. Again, the two thematic experts (*Interviewee 2-S and 13-S*) responded differently, as they questioned the far-fetched consequence for inaccessibility and whether it is an issue in reality. They relied on their insight knowledge and stressed that they were able to retrieve the same amount of information, including other possible consequences such as the flooding of basements, from Map 1. They, therefore, preferred using Map 1, which they called "less subjective". This preference for Map 1 is shared by the three other interviewees (*Interviewee 4-N, 6-C, 12-N*), as they said that the focus on inaccessibility made the issue smaller than it was by neglecting and, therefore, missing other consequences such as water damages to basements: *"I can imagine that certain areas have large water nuisance, but that does not automatically mean there is also an inaccessibility of roads. I think that if you only show Map 2 you miss a lot*" (*Interviewee 6-C*). They preferred the simplicity of information and clear gradation of blue of Map 1, but did see Map 2 as an extra argument to underline the story and issue of water nuisance of Map 1 (*Interviewee 6-C, 9-N, 12-N, 14-N*).

The preference for the simplicity of information became even more important when interviewees started to question whether the data behind Map 2 was correct. Four interviewees (*Interviewee 1-C, 5-C, 8-N, 13-S)* generally did not think that the visual image and data was corresponding with reality. This caused the conversation to focus on whether or not the data was correct and which methods and information were used to determine the water nuisance depth instead of the issue of water nuisance or damages. Besides, this also caused none of these interviewees to potentially use the maps towards colleagues.

The questioning of choices made during production and the data showed was amplified for Map 3, shown in Figure 31, which interviewees considered to be based on more choices made by the producer, as shown by the following quote: *"I think this is just a bit too much. It directly makes a lot of choices, while there are actually many more choices to be made. You can also look at what is being renovated or demolished and that would show that there is way more possible" (Interviewee 5-C).* Instead of focusing the discussion on the areas that are highlighted as chances, and discussing the possibilities, all interviewees either wondered about the underlying arguments for choosing those specific areas or emphasised their surprise of the limitedness and wonder why other areas are nót chosen as chances. This is exemplified by the following quote: *"I am inclined to think: Are these the only areas where there are chances? How does that work? And why?" (Interviewee 10-N).* This thought is continued by an interviewee, which emphasises that as a municipality you should never aim for too few chances (here only four areas): *"This is the same for if you want to realise something. For example, sometimes you have to cross water, so you aim to build five bridges. In the end, you might only get three, because you run out of money or the other two were not deemed necessary. But if I only draw one bridge you can only get one or perhaps even none. So I always say, put your ambitions high" (Interviewee 11-N).*

Figure 31: Small representation of Map 3, without the substantiating text

This general preference of showing a broader array of chances continued for Map 4, shown in Figure 32, as seven interviewees (*Interviewee 1-C, 2-S, 6-C, 7-C, 9-N, 10-N, 12-N*) would have liked to combine Map 4 with Map 3. This way, the chances of planned sewage works would be combined with the spatial opportunities of Map 3 to get a more comprehensive picture. They would also have been able to see what the differences between the two were. Besides, they would also like to extend the coupled 3-4 Map to other city-wide planned works, such as the demolition of buildings or the restoration of canal quays:

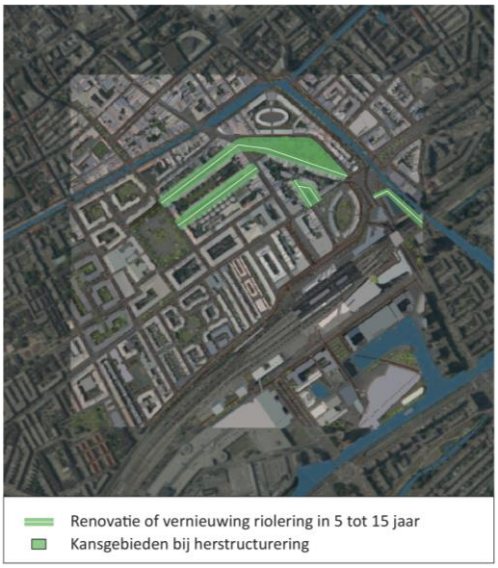

Figure 32: Small representation of Map 4 without the substantiating text

> *"I think this map is quite limited. Especially the chance to strengthen the green-blue structure [Map 3]. You can take that much broader. You have greenery structures, tree rows, tree driplines that you can also use for infiltration, and existing roofs, which you can work on together with the city instead of just the municipality. So, to not just focus on demolition projects and new constructions, which I presume it is focused on. Then the map becomes way more interesting if I may say so, because it will show more chances. Now it feels like the entire neighbourhood has an issue, and you are going to fix it in those four areas. That is too limited. There is way more possible" (Interviewee 7-C)*

Besides this, talking about overlaying the maps and extending the chances caused most interviewees to only give a short individual reaction, after which talking in 'we' or 'us' was adopted, while others started talking in collective pronouns straight away (*Interviewee 13-S and 14-N*).

7.2 Interaction with Maps

The second overarching theme that has been identified is 'interaction with maps'. While the conducted interviews were one-on-one with individual employees, this theme consists of the individual's estimation of how the maps could be used in interaction with colleagues and their expectation of how other colleagues would interpret and understand the maps. In all interviews, when asked about how they would use the maps during interaction with other colleagues, most interviewees started referring to the maps as building a *"story"* or the *"goal"* or *"communication goal"* behind the map. For six interviewees *(Interviewee 1-C, 6-C, 7-C, 10-N, 11-N)*, the question initially remained unanswered as they stated that this would depend on the goal or story behind it or why you would like to use the map, as exemplified by the following quote: *"That is difficult to say, because that depends on what you want to tell your own colleagues" (Interview 10-N).* For these interviewees, a second question on what they would like to say was necessary.

From this focus on stories or communication goals behind the maps, three distinct ways maps could function as a story or with a certain (communication) goal in interaction became apparent. First, two stories behind individual maps will be discussed: the tendency to act and the ability to connect with (other) departments. The tendency to act focuses on the difference between Map 1 and Map 2, whereas the ability to connect discusses Map 2 and 4 both separately and together. Afterwards, these individual stories are brought together and discussed as a whole, as 8 out of 14 interviewees stated that a map does not stand alone, but is through a combination of maps that make a story.

7.2.1 Map 1 and Map 2: Tendency to Act

The difficulty of Map 1 to deduce whether the number of centimetres was an issue or not, as discussed in Section 7.1, was in line with the communication goal to signalise the issue which 7 out of 14 interviewees had in mind. They stated that Map 1 mainly signalised the problem and underlined the general issue of extreme rainfall events. While for these six out of these seven interviewees this signalisation did underline the urgency (*Interviewee 1-C, 10-N, 12-N*) or gave them the ability to convince or remind others that there is a problem (*Interviewee 4-N, 5-C, 14-N*), four interviewees (*Interviewee 3-N, 10-N, 11-N, 14-N*) stated that with merely signalising the issue the translation towards action would remain difficult. As an example, Interviewee 11 noted that signalising the issue causes people to mainly observe and be made aware of the information, but that this does not result in action: *"This [Map 1] is just signalising the issue and I always notice that if people signalise nothing happens. People think 'oh well, that knowledge is nice, but we shall see'."* (*Interviewee 11-N*)

In contrast, Map 2 caused multiple interviewees to start talking about the necessity to take action and listing multiple measurements that would be able to do so. Four interviewees (*Interviewee 5-C, 10-N, 11-N, 14-N*) explicitly described the difference between Map 1 and 2 by saying that Map 2 focused the story on taking action and thinking of measurements, by raising questions such as *"What are we doing then? How are we going to tackle this?"* (*Interview 10-N).* They stated that Map 2 had the ability to start a discussion around those questions of action. Interviewee 11, therefore, described Map 2 as a way to put it on the agenda *('agenderen')* compared to the signalising *('signaliseren')* of Map 1: *"You place it on the political agenda. This [Map 2] is a tool to maybe have it faster or more specifically on the*

political agenda, which may be causes resources to made available earlier or that they are forced to think about the city differently" (*Interviewee 11-N*).

7.2.2 Map 2 and Map 4: Ability to Connect Departments

With over 6.800 employees (Gemeente Den Haag, 2018), divided over 8 distinctive services of which each service is responsible for a certain duty of care, four interviewees *(Interviewee 3-N, 4-N, 9-N, 14-N)* again expressed that they often have an issue of finding each other, as also mentioned in the context interviews of Chapter 4. They mentioned that since every service, separated into speciality teams, has its own focus, the employees of different departments such as Mobility and Sustainability can work at cross purposes: "*I notice that within our organisation this is not really managed well. You miss the link between the different departments"* (*Interviewee 3-N*). This is further exemplified by Interviewee 4: "*That is now and again an issue at Municipality land, as everyone on their, sounds disrespectful, little island tries their best to realise all the goals of the Municipality of The Hague which we drafted together. And at that speed, you could just forget your colleagues sometimes"* (*Interviewee 4-N*). This issue becomes is in line with the notion of the two thematic experts, *Interviewee 2 and 13*, that they are not always noted or involved with water nuisance projects, while water management is their responsibility within the Municipality of The Hague.

The issue of sometimes not being able to connect departments or certain people working and remaining within their own speciality and goals was highlighted and said to perhaps be resolved through Map 2 (mentioned by the two urban planners) or Map 4 (mentioned by 6 interviewees) with each a different approach. On the one hand, the urban planners noted that Map 2 could bridge the issue of water nuisance from a climate issue towards a shared issue. On the other hand, Map 4 caused most interviewees to talk about an inclination to interact, bring people together, and think of solutions together. Because of this, the section will first focus on Map 2, which will be followed by Map 4.

7.2.2.1 Shared Experienced Issue

The two urban planners, *Interviewee 3 and 11*, noted that the framing of Map 2 has the ability to make climate change issues, such as extreme rainfall events, a shared story or problem that affects not just the sustainability department but multiple disciples throughout the municipality. They said that by coupling extreme rainfall events to a direct consequence outside the field of water management, here the inaccessibility of emergency services, you could place the issue on "other department's plates". This way, the story told behind Map 2 could embrace the fact that sustainability or climate change should not be a loose or independent story. It should be a shared problem that affects everyone, all the departments, within the Municipality of The Hague:

> *"You do not only have the sustainability interest. You couple the interest directly to a piece of Mobility, which we are also there for. You might also couple it to the economy or the accessibility of shops. This way you make sustainability interwoven with the project assignment. It is not just a loose element anymore, which I unfortunately sometimes see happening and it becomes one of many chapters, but it now can become an integral part of the policy or other departments" (Interviewee 3-N)*

> *"I think that it does not just become a climate story. It becomes a story of safety. It becomes a story of liveability. So, the more different disciplines you appeal to, the more support it gains from different departments within the municipality or the higher it comes on the political agenda, and the more councillors have to deal with it. [..] It becomes a broader story. You*

actually say, no this is not just a problem of the street, this is a problem for all of us." (Interviewee 11-N)

That the framing of Map 2 might create a shared experience of the issue also became visible during another interview with an expert in greenery (Interviewee 4). While during Map 1 the discussion with the interviewee was focused on the lack of a serious issue of water nuisance for trees within the Municipality of The Hague, his first reaction on Map 2 was: *"What you actually see is that, of course, I was thinking rather one dimensional, I was really looking at the greenery and the planting of trees, but of course this is a much more important issue than just the trees"* (*Interviewee 4-N*).

While this only happened for one interviewee, this might happen more frequently if the consequence-map was extended to multiple consequences that would address the different departments. Four other interviewees (*Interviewee 6-C, 7-C, 9-N, 12-N*), besides the two urban planners, suggested the need for an extension of consequences as well. They mentioned an extension of consequences to, for example, potential damages to (monumental) buildings, damages to basements, inaccessibility of shops, damages to vital infrastructure such as electrical transformers, or overflowing ditches. This might even be taken a step further to include the other two climate stress themes: drought and heat stress. Without having a question in the interviews focused on the other climate impacts, seven out of fourteen interviewees mentioned the need to also look at those consequences and maps as well. This way, you could see overlapping critical areas between the three themes. Combining these insights, Figure 33 shows a hypothetical visual representation of the perceived shared story by the urban planners.

In contrast, it is interesting to note that, apart from Interviewee 4 and 10 which did not discuss this extension, the five interviewees that did not mention the possibility of extending the consequences maps are the same interviewees (*Interviewee 1-C, 2-S, 5-C, 8-N, 13-S*) that did not see Map 2 as an issue, and either had the thematic knowledge to deduce the consequences of Map 1 themselves or questioned the data.

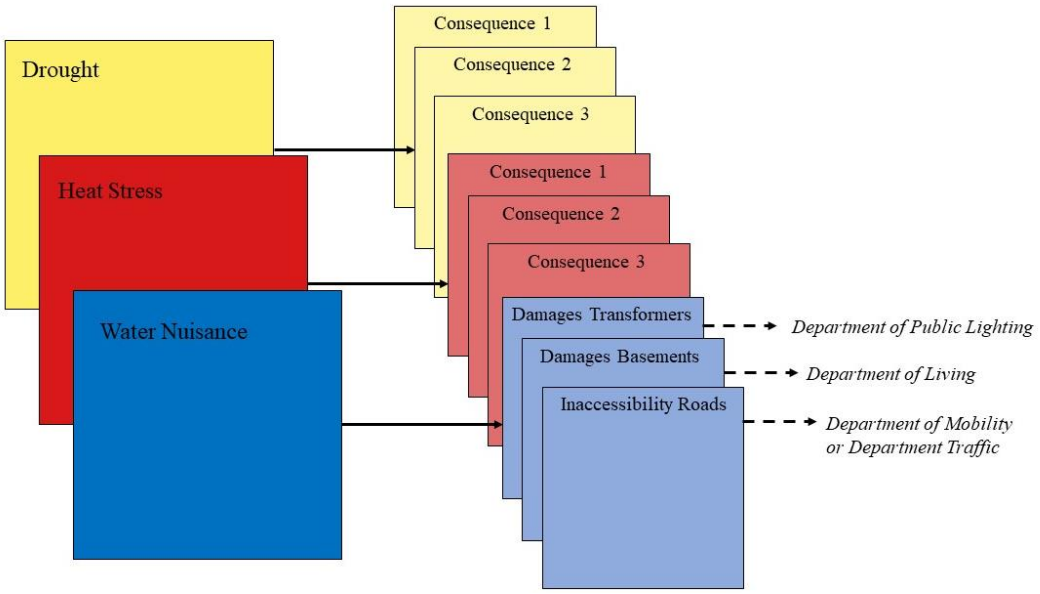

Figure 33: Visual Representation of Problem Identification Map Layers, which each speak to a different hypothetical department, causing an overall shared experience of the issue

7.2.2.2 Shared Chances of Connection

Besides that the framing of multiple 'consequence maps' might induce a shared experience of the issue or interest, multiple interviewees reacted positively to the ability of the extended and combined chances

version of Map 4, as discussed in Section 7.1, to create an overview for people of different departments to find each other and to couple chances ('*meekoppelen*'). Currently, without having a map similar to Map 4, five interviewees (*Interviewee 3-N, 4-N, 7-C, 9-N, 14-N*) note that chances are sometimes missed because the question of whether the department wants to join the project ('*meekoppelen*') arrives on short notice or it is generally unknown what interesting projects other departments are working on. This is exemplified by the following quote: *"I think that, in many ways, there are a lot of seizable chances, but you have to point them out together. You have to enter a conversation about them and then together also weigh the options" (Interviewee 6-C).* Because of this, they said that city-wide maps, with an overview similar to Map 4, can make colleagues aware of what other departments are planning on working on, which allows reaching out to them and work together. Besides, having an overview of future plans might give the ability to think ahead, plan in time, and reserve resources on time (*Interviewee 3-N, 4-N, 9-N, 11-N*).

While most interviewees react positively and note the chances that an overview map with future projects can bring, the next step is whether these chances are actually taken and result in reaching out to each other and perhaps even action. Interviewee 9 questioned this, as he notes that *"I do think that this might require a different working method. It requires quite some assertiveness"* (*Interviewee 9-N*). He is positive about having an overview of possibilities and projects, which is one thing, but emphasises that having the assertiveness to couple them is another. On the other hand, Interviewee 12 is more positive of his colleagues, and their municipal ambition, to be assertive. He sees Map 4 as a map that creates action, fitting the civil servant's ambitions ('*tussen de oren van een ambtenaar'*) to recognise couple-chances ('*meekoppel kansen'*):

> *"You now have the chance to couple chances to the sewage repairs. That is a chance you have to take now. It cannot wait 5 years, because then the first part of the sewage is already repaired and the chance is over. Yes, these kinds of maps help enormously. Of course, for the other maps [Map 1 or 2] you can see a kind of urgency, because yes that rain shower can fall, but it can fall in 25 years, in 5 years or 100 years, no idea, and that does give urgency, but not for tomorrow or the day after tomorrow. This gives clarity. This is something concrete that we can do something with. […] Here, you couple a concrete chance to something that within the municipal system has urgency." (Interviewee 12-N)*

7.2.3 One Combined Story

While every map has its own main story, 8 out of 14 interviewees emphasised that the maps should be combined to create an overall story. Individually, Map 1 mostly conveys the story or message of signalising the issue or urgency of extreme rainfall events. Map 2 either creates a story around measurements and taking action to tackle this issue or, for the urban planners, creates a story around a shared issue. In addition, the extended Map 4 might create a story or message around finding each other. These individual maps combined create a story that focuses on determining and emphasising the future issues which need to be dealt with, mainly through Map 2 or for a smaller group Map 1, and will be followed by the possibility to couple the solutions for these issues to already planned future projects (Map 4), as exemplified by the following quote: *"They bring one image together: there is water nuisance and this is where you can do something about it, and guys, the issue is really big because if we let it get this far the emergency services also cannot reach it any more, so to speak. They all bring a joint story together" (Interviewee 14-N).*

While the interviewees emphasise that this should be the way they focus and tell their story, two interviewees (Interviewee 7-C and 13-S) question whether this is the case in practice. They stated that

for the Municipality of The Hague Map 4 with planned works is leading. They said that municipal employees start their story from Map 4, asking themselves what will happen, and then afterwards look at Map 2 or 1 to see if there are more possibilities. They emphasised that if the urgency to act according to Map 2 or Map 1 would be large enough, the Municipality would act pro-actively or adopt adaptation measures. If it was, then the story should have been the other way around: from 1 to 4: what is the issue, how are we going to deal with it, and are there other departments that want to couple their ambitions to our climate adaptation ambition? However, in practice, they emphasised that this is not the case and employees start from the planned infrastructural works (4 to 1).

In addition, six out of these eight interviewees also mentioned the necessity for balance in their stories. They state that a story around chances is nice, but that you need the necessity and substantiation to talk about these chances through the issues. It, therefore, requires a story with a balance between these two types of maps, as shown by the following quote: *"It is about how you build your story. If you only mention the issues, it will be a grumpy story. If you have chances, you offer people an alternative. If you only talk about chances, people might forget what the issue was about" (Interviewee 11-N)*

7.3 Visual Representation of Maps

The third and final overarching theme that has been identified is the 'visual representation of maps'. Overall, most interviewees reacted positively on the usage of maps to bring clarity, substantiate their story and show visually the issues and consequences. The specific comments that the interviewees made about the visual layout and representation of the maps can be found in Appendix F. Each figure only shows the comments that have at least been mentioned by two interviewees.

7.4 Conclusion

As discussed throughout the chapter, three distinct themes were identified: interpretation, interaction and visual representation. For interpretation, three different interpretations have been observed: the interpretation of the two urban planners, the two thematic experts and a large part of the interviewees (general). An overview of the key interpretations is shown in Figure 34.

As can be seen in the Figure, there is already a step towards a type of interaction in the individual's interpretation, e.g. actions necessary (Map 2) or finding each other (Map 4). However, the *influence* of these maps on these types of interactions is often referred to as a substantiating or visual representation of a (told) story. Through which the interpretations mentioned by the interviewees (in Figure 34) are the stories underlying the map(s). While these maps all have their individual stories, 8 out of 14 interviewees emphasised that the maps should be combined to create an overall story. This combined story of the maps focused on determining and emphasising the future issues which need to be dealt with, mainly through Map 2 or for a smaller group Map 1, followed by the possibility to couple the solutions for these issues to already planned future projects (Map 4).

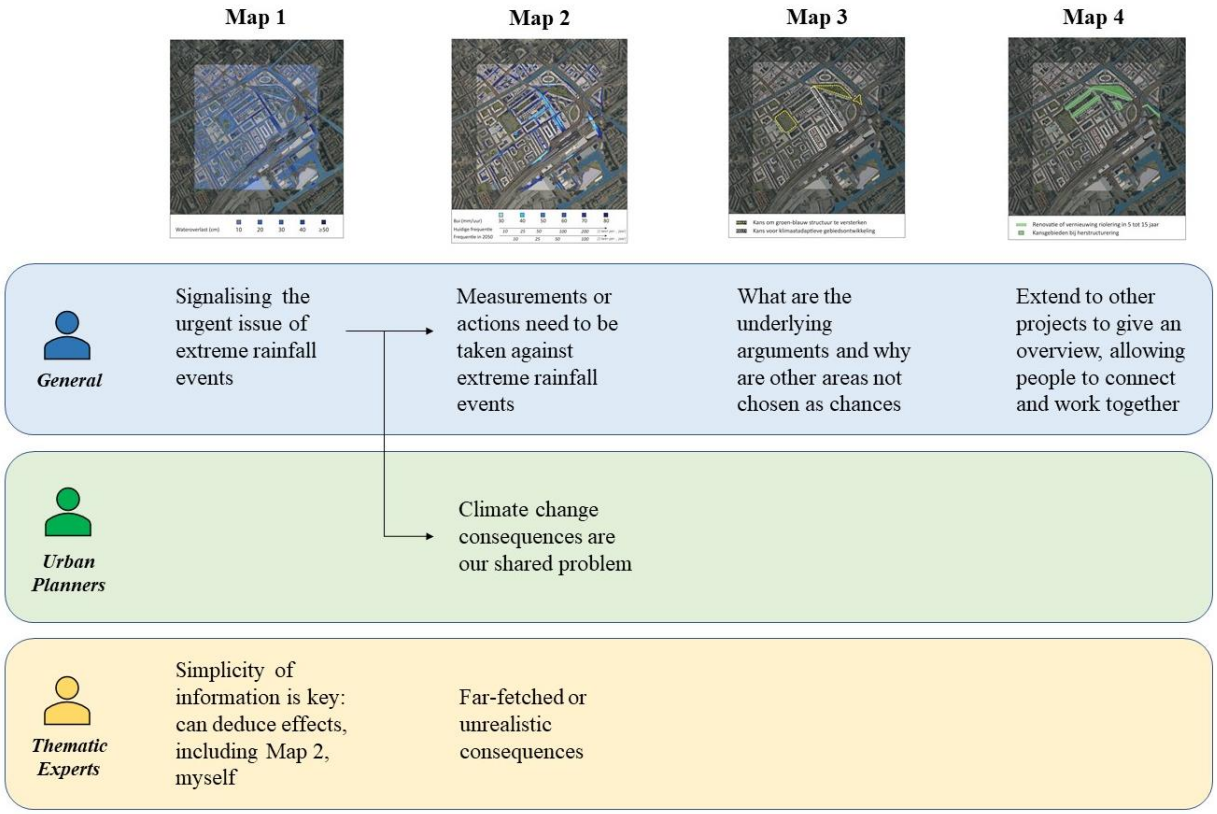

Figure 34: Overview of the key interpretations of the municipal actors. The interpretations listed are a summary of the findings and are not direct quotes. A distinction has been found between the two urban planners, two thematic experts and the general interpretation.

Discussion and Conclusion

This study integrates aspects of the master's degree in International Land and Water Management and the master's degree in Communication Design for Innovation. Because of this, the Production Phase leaned towards the water management aspects of the study, by incorporating the Tygron Geodesign Platform, assessing the adaptation tipping points and gathering a clear understanding of the water management situation of the Huygenspark. On the other hand, the Circulation Phase emphasised on the communication sciences aspects of the study, through integrating an individual's interpretation and interaction with colleagues based on interviews with visual maps. Both aspects will be bridged and discussed in the Discussion (Chapter 8). This is followed by an overall conclusion of this study by answering the main research question (Chapter 9).

Chapter 8 : Discussion

Chapter 9 : Conclusion

8

Discussion

This study was carried out for the master's degrees in International Land and Water Management and Communication Design for Innovation. The study aimed to assess how visual framing of extreme rainfall model results influences the interaction between municipal actors. In this chapter, the results to reach this objective are critically discussed and put into their larger scientific and social context. In line with this, this chapter starts by comparing the results of the hydrological assessment to other authors (Section 8.1). This is followed by two sections bridging and reflecting on the findings of the reaction of the municipal actors to the extreme rainfall model results. This reflection is done through the lens of the theoretical framework of phase two and through comparing the results to previous studies. First, the visual framing effects concerning the individual's interpretation of individual maps are reflected upon (Section 8.2). This is followed by a section bridging these interpretations of individual maps to discuss their influence on the interaction through story-telling (Section 8.3). After reflecting on the results, the next section provides a critical reflection on the methodological steps and decisions made throughout this research (Section 8.4) and listing the key implications of these findings (Section 8.5). The chapter is finalised by summarising the key recommendations for further research and practice (Section 8.6). These recommendations have been discussed throughout this chapter.

8.1 Reflection on Results of the Hydrological Assessment

The focus of the adaptation tipping point on the accessibility of roads for emergency services and cars created for the majority of municipal actors a sense of severity and the need to take action. This indicates that the chosen threshold indeed corresponds to what the majority of municipal actors considers to be important. This focus is in line with the suggestion by Koetse and Rietveld (2009), which state that the identification of vulnerabilities in the road network is indeed critical for developing an adaptation strategy. The focus on emergency services is also in line with the shift in flood discourse in the Netherlands, which shifts the focus from 'preventing' to 'improving the emergency management and reducing consequences' (Sayers et al., 2013). Nevertheless, previous studies have a strong emphasis on creating flood-resilient buildings, neglecting the importance of a system approach on the impact of (pluvial) floods on the (in)accessibility of roads for emergency services (Lhomme et al., 2013). As this study shows that municipal actors consider it an important issue, it would be important to extend future research on the (indirect) flood impacts for emergency services, such as the response time.

In addition, the results of the Tygron Geodesign Platform model show that especially the Stationsweg and the two tunnels (at the Rijswijkseweg and underneath the train tracks) will have large issues in terms of emergency service accessibility during extreme rainfall events. These problematic accessibility areas are in agreement with the master thesis by de Jonge (2021). In her study, a sewage expert at the municipality even recognises the issue by stating: *"The tunnel at the Rijswijkseweg is sometimes flooded and perhaps indeed impassable once in 10 years"* (de Jonge, 2021, p.139). De Jonge (2021) relates these results to the height map of The Hague, which shows that the Huygenspark is the lowest area in

the city. However, to directly relate a water nuisance issue (and its water depth level) to an issue for the accessibility of emergency services might be too simplistic. Coles et al. (2017) show that the accessibility of emergency services should account for more than the water depth. They show that modelling accessibility is a complex undertaking consisting of a multitude of factors: the road network of emergency services, the different flood mechanisms, and the location of the ambulance and fire and rescue services, as well as the location of vulnerable inhabitants or elderly homes (Coles et al., 2017). Nevertheless, this initial assessment does show that the Municipality of The Hague, as well as the emergency services, could improve their resilience by studying the structure of the network and considering alternative paths, as the water depths at the Stationsweg and the two tunnels are critically high for relatively small rainfall events. This study, therefore, recommends extending the analysis into the municipality's road networks, location of vulnerable inhabitants, and the required response time of emergency services.

8.2 Reflection on Results for Interpretation and Visual Framing of Individual Maps

While it has been mentioned by six interviewees that the constructed story depends on what the interviewee would like to bring across and to whom, several characteristic reframes of maps become apparent which align with their initial personal interpretation of the visual content. In line with this, the influence of framing through an individual's cognitive images of psychological distance and valued outcome (of loss) is first discussed (Section 8.2.1). This is followed by a section on the reverse effect of the individual's own mental model on the interpretation of the visual framing (Section 8.2.2).

8.2.1 Psychological Distance and Value of Gains and Losses

In this study, it was found that interviewees with limited detailed knowledge considered it difficult to understand whether the numbers of centimetres of water nuisance (in Map 1) were an issue or not. This is in contrast with their interpretation of the adaptation tipping points map (Map 2), which made the issue more concrete and mentally visual for 9 out 14 interviewees. This contrast is in line with the notion of psychological distance in the Construal Level Theory by Trope and Liberman (2010). This theory describes that people focus on concrete and specific features when objects or events are perceived as psychologically closer (Lower Construal Level). In this case, through the mental image of ambulances in the streets instead of water nuisance in general.

This study also shows that the adaptation tipping points map (Map 2) causes actors to talk about the severity of the issue, as well as needing to take action, instead of merely signalising the issue (Map 1). This is in agreement with the study by Scannell and Gifford (2013), which shows that providing individuals with local climate information increases their engagement and willingness to act. This is because people tend to be more concerned with the current status, also called status quo bias (Kahneman et al., 1991; Schuldt et al., 2016). Besides, feeling personally threatened by climate change has also been linked to an increase in support for a range of policies to address the issue (Zahran et al., 2006). However, not all studies find support for these results. Schoenefeld and McCauley (2016) show that local or distant frame does not necessarily have a strong influence on pro-environmental behaviour. In addition, Spence and Pidgeon (2010) show that changing psychological distance did not affect an individual's inclination to act. Their study concluded that a nearer climate change frame resulted in a decrease in perceived severity. They attributed this result to previous findings which show that individuals perceive climate change to impact people in other, distant, counties instead of themselves locally (e.g. Leiserowitz, 2005; Räthzel & Uzzell, 2009). This difference might be because Spence and Pidgeon (2010) changed spatial distance, whereas this study changed social distance.

Another explanation could be that municipal actors are more concerned and impacted by the combined effect of frames: framing the issue as a personally close security issue (near frame) inside a loss frame. Bilandzic et al. (2017) show that the combination of a near frame with a loss frame (Map 2) increase the feelings of fear and guilt. Spence and Pidgeon (2010) demonstrate that 'fear framing', a more extreme version of a loss frame, has a significant effect over the normal loss and gain frame and increases the perceived severity of climate change impacts. Fear framing has been demonstrated to be an important factor to encourage behavioural changes to mitigate climate change consequences (Nisbet, 2009). This is in line with Protection Motivation Theory (Rogers, 1983), an important cognitive motivational theory in health sciences, which describes that if individuals are presented with a threat, they will adopt mitigating behaviour. While this fear framing was not a part of the theoretical framework, and therefore not a central concern of this study, this affective fear difference might be a key aspect to explain the difference between the adaptation tipping points frame of Map 2 and the frame of Map 1. This might especially be the case since the socio-political objectives underlying the framing of Map 2 are identified to be the ones that should be considered serious or threatening by the employees. Because of this, it is strongly recommended to extend the visual maps, as well as the theoretical framework, in future research to the aspect of fear framing. This should take into account how a stronger affective, or emotional, response influences the non-rational interpretation of actors on climate change consequences.

Besides, the influence of the loss frame also became visible when comparing the interpretation of the loss maps (Map 1 and Map 2) and that of the chance maps (Map 3 and Map 4). While the interpretation of the loss maps focuses on either the severity or the actions necessary, the interpretation of the chance maps focuses on finding each other, bringing people together and bringing hope. This is in line with the notion of loss aversion, in which people experience losses heavier than the equivalent gain (Kahneman & Tversky, 1979). This way, the loss maps are perceived as heavier, or more severe, and make people inclined to talk more about negative emotions and actions. This also corresponds to Chang and Wu (2015) showing that gain frames generate positive feelings in contrast to loss frames. In contrast, studies have also shown that the positive reaction through gain frames increase pro-environmental behavioural intentions and policy support (e.g. Jacobson et al., 2019; Spence & Pidgeon, 2010). In this study, while the loss frame creates a general belief of severity and urgency, it might be easier and more important to generate support and gather (the right) people through the gain frame to result in adaptation mainstreaming actions ('*meekoppelen'*). Especially if you compare this behavioural intention to the interaction issue of the Municipality of The Hague (Chapter 4), which is their individual's focus on the department team's objective amplified by the budget restrictions, instead of the overarching municipal climate goal. Therefore, a shared experience of finding each other through gain frames might be more important to bridge this interaction issue than the felt severity of the loss frames. This shows that while the loss frames do generate a focus on action and severity, the interpretation of the gain frames might be just as important for adaptation mainstreaming actions.

8.2.2 Mental Model

The study also shows that a single map of adaptation tipping points (Map 2) can be interpreted in three distinct ways. In contrast to the general story of concrete action, Map 2 created a story of a shared issue for the two urban planners, whereas it created a polarised reaction of far-stretched consequences for the two specific thematic experts. The only difference here is the type of person, their job description or their pre-existing way(s) of looking at the issue. This is in line with the notion of mental models in cognitive sciences. As described in the theoretical framework, mental models are a filter through which people observe information (Nisbet & Mooney, 2007). The story constructed is, therefore, not only shaped by the information the interviewees receive, but also what they *prefer* to believe and see (e.g.

Johnson & Eagly, 1989; Kahneman & Tversky, 1996). This is similar to the study by Schoenefeld and McCauley (2016) which shows that local or distant frame does not have a strong impact, instead, the self-interest and previous value orientation impacted their perceived importance and pro-environmental behaviour.

In addition, the interpretation of the two urban planners showed that the adaptation tipping points map (Map 2) might have the potential to make climate change consequences a shared 'our' issue that bridges and addresses departments beyond the field of water management. Especially if the maps are going to be extended to other consequences that each would link to a department, as mentioned by six interviewees. In social identity theory, collective language through 'our' or 'we'-referencing is important to create a shared social identity or to undergo organisational identification (Turner, 2005). Collective language helps signal solidarity and increases the group's commitment towards the issue (Hornsey et al., 2005). Studies have shown organisational identification is extremely important for cooperation and for making decisions in the organisation's interest (e.g. Edwards, 2005; van Dick, 1992). While the end goal of the story by the urban planners might be equal to the stories of the other municipal actors by stating 'we have to do something about this issue', the angle at which the discussion is started is quite different when focusing on the *we* in '*we* have to do something about this', and when the story is focused on *this issue* in 'we have to do something about *this issue*'. Since this study only spoke to two urban planners in contrast to twelve other municipal actors, it would be interesting to explore the potential of translating climate change impacts into socio-political objectives to create a shared experience of the issue further. This might help to position climate change consequences into a shared responsibility and put it higher on the municipality's political agenda.

To extend on the difference between the two urban planners and the rest of the interviewees, this difference might be explained through the difference in thinking style between linear or non-linear thinkers. Most people are inclined to think linearly, preferring logical reasoning to produce consistent outcomes (Groves & Vance, 2015). This is in contrast to non-linear thinkers, similar to design thinkers, which expand an issue into multiple solution directions through associative thinking (Groves & Vance, 2015). As urban planning is a complex process that requires non-linear thinking by bringing various perspectives and ambitions together and needing a far-future and wider perspective of the city, either their educational and job background might make them more inclined to non-linear thinking or non-linear thinkers might be more inclined to be urban planners. Since this study only spoke to two urban planners in contrast to twelve other municipal employees, it is interesting to explore this difference in interpretation of visual frames between urban planners and other municipal employees in future research more. This could explain the relationship between urban planners and design or non-linear thinking clearer and which aspects of visual frames triggered their non-linear thinking compared to the linear thinkers.

The study also showed that when a map did not align with the pre-existing perspective on the issue, interviewees either rejected the map or did not want to use the map further. This was seen for Map 3, which was in disagreement with the municipality's perspective that almost every area could be a chance, as well as for Map 2, when the thematic experts' interpretation and resulting implications were in sharp contrast with the general or non-thematic experts. This reaction is in agreement with motivated cognition models, which suggest that people discount new facts that go against their attitude (e.g. Johnson & Eagly, 1989; Kunda, 1990). This is similar to the notion of confirmation bias (Nickerson, 1998). The notion that a single visualisation can create such contrasting or polarising interpretations or discourses is relatively new and under-researched (Gommeh et al., 2020). As this polarising effect of a single visual also became visible in this study, but the population group is relatively small, it would be

interesting to have future research on the role of visualisations, such as climate tools, on confirmation bias.

The attitude-confirming influence of mental models can also result in unexpected (new) stories, such as the story around Map 4. Map 4 was initially produced as a simple map that shows the sewage repairs that are planned in the next 5 to 15 years with the potential of coupling chances (*'meekoppelkansen'*). The interviewees extrapolated this notion of coupling chances by constructing a story around finding each other and working together. This shows that while a producer can carefully choose the stylistic features and message of a visual, a simple map can be moulded and reframed to a broader story just as much as a carefully constructed one. The reason for this positive reaction and extrapolation of the story of Map 4 might be explained through their municipal viewpoint focused on finding these couple-moments, as explained in Chapter 4. As the Map strongly fits with this perspective, and their current reference point, they might be quicker to adapt and extrapolate the story.

8.3 Reflection on Results for a Combination of Visual Maps

While every map has its own main story, 8 out of 14 interviewees emphasised that the maps should be combined to create an overall story. Together, the maps could provide guidance or substantiation to the story or stories that the interviewee wants to bring across to their team members. This story can be to convince others, but it can also be to start a discussion or to weigh different options. This visual storyline corresponds with the dynamic interpretation of *'visualisation'* by van Beek et al. (2020) in which actors interpret the map, make sense of it, and give a (new) meaning to the image through reframing. Visual maps, therefore, influence the interaction by helping people to engage with the story and translating the story into an image. They can be seen as a *'story support tool'*, deduced from the concept of decision support tools, which are tools to aid the decision-making process. As the name suggests, the visual maps support the story that the individual wants to tell and show to others; their interpretation of reality. Within the Municipality of The Hague, each individual constructs a slightly different story, but the overarching messages or story can be traced back to their thematic expertise, job description (for urban planners) or cognitive biases.

Visual maps, therefore, could reveal contested facts, values and concerns of municipal employees. This indicates that they could reveal various discourses. Discourses are an *"ensemble(s) of ideas, concepts, and categorisations […] through which meaning is given to physical and social realities*" (Hajer, 1997, p. 44). This is in line with a recent study by Gommeh et al. (2020) which coins the concept of *'visual discourse coalition'*. Visual discourse coalitions are created when visuals and discursive storylines become a coherent whole and networks of actors are created with similar discursive and visual storylines. Gommeh et al. (2020) argue that four forms of discourse coalition evolution: confirmation, disintegration, integration and polarisation. As described in the previous section, confirmation in which the visual repeats or strengthens the discourse, as well as polarisation (thematic experts) and integration of different ways of looking at an issue (urban planners) have been observed. While this concept has not been applied in this study, this research contributes and aligns to the importance and notion of visuals as story support tools in which discourses become apparent.

While the theoretical framework, as well as the study by Gommeh et al. (2020), focuses on the interpretation of a single visual, this study also shows that individuals use multiple visual maps and reframe them together into a coherent story. These multiple maps can, together, be seen as a mosaic puzzle that becomes a whole, as shown in Figure 35. This way, the interviewees make their story more balanced and 'cherry pick' the maps that fit into their mosaic coherent story. Often, with these maps, the story starts with the problem, making people aware of the necessity to act, and the severity of the

event, which is then followed by the chance map(s) with the story of offering hope and a way out. This story is, again, part of a larger story, namely the climate change consequences in general. While this part focuses on water management of extreme rainfall events, droughts and heat stress are also two main focus points of the Municipality of The Hague. Because of this, the mosaic story of Figure 35 should be seen as a small mosaic of a larger puzzle.

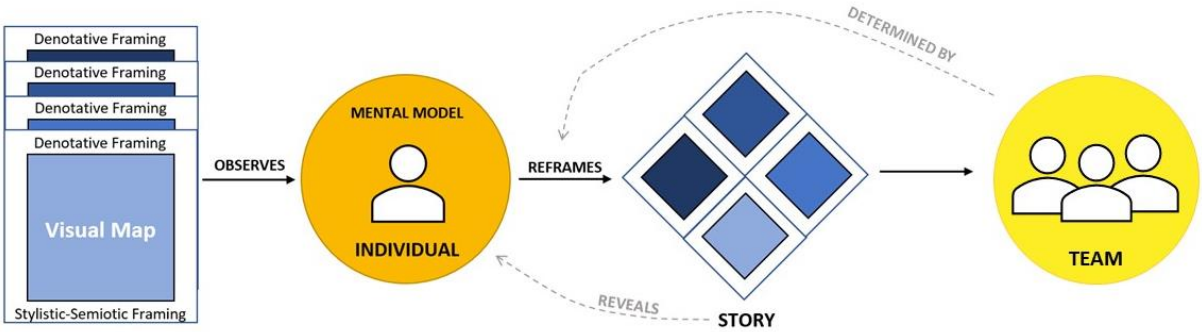

Figure 35: Graphical Representation of how individuals reframe individual maps to together fit a coherent story. The story around and with these visual maps can reveal their mental model: their values, concerns, knowledge structures. This story is also dependent on which team, and which individuals in that team.

8.4 Reflection on Methodology

This section critically reflects on the methodological choices made during the study which could impact the results of the study. This section follows the methodological steps, as described in the Methodology Chapter (Chapter 3). Overall, it is important to be aware that this study is a bridge between the field of communication sciences and water management. While this creates rich discussions and an integrated analysis of the issue, this trans-disciplinary research also creates challenges. Bridging two fields requires a constant balancing between two different, and sometimes polarising perspectives on theories, methods, end results, as well as directions towards a solution. The integration of perspectives and knowledge can make the structure of the study less transparent or well-defined and in constant need of reflection throughout the process.

Besides trans-disciplinary, the study was exploratory. The study aimed to describe the influence of visualisations, including adaptation tipping points, on the interpretation and interaction of municipal actors by observing their words and actions during interviews. The descriptive results were then assessed through the theoretical lens to discuss how these visual maps influence interaction. The study, therefore, did not make use of a hypothesis to guide the study. This also limits the study's ability to make predictive or prescriptive statements about what will likely happen during the next interaction and what should be done. It should be seen as the first step to describe the behaviour around visual maps from which more predictive or prescriptive research can be done.

8.4.1 Theoretical Framework

This exploratory nature caused the development of the theoretical framework to be done through a non-systematic literature review. While this narrative literature review provided this study with the necessary flexibility to cope with its exploratory nature and deal with unforeseen discoveries, the selection criteria for certain articles and the search query is more subjective, which potentially leads to biases. It is, therefore, also more difficult to reproduce the framework, as another research might come across different aspects or concepts to explain and look at the situation.

Due to the complexities between theories and concepts, the theoretical framework has been built in two phases. First, it mainly consisted of cognitive bias theories (Prospect Theory and Construal Level Theory) in combination with adaptation tipping points. After the results, this was extended to the framework as it is now to analyse and understand the findings. Due to these complexities, it was difficult for this study to have this framework at the beginning. However, it cannot go without saying that the production of visual maps, as well as the interview guide, might have been more focused on the framework and would impact the results if this theoretical understanding would have been determined at the beginning of the study.

Furthermore, while the critical review paper of Interactive Team Cognition by Cooke et al. (2013) shows the potential of the theory to move the focus from individuals within a team towards the interaction between team level and organisational level, the theory misses substance. It does not elaborate neither substantiate the notion of interaction nor how it can be measured. Through this, the theory feels like 'wishful thinking', in which the formation of a theory is based on what might be pleasing to imagine and work, rather than on evidence. This study tries to accommodate this gap by combining the theory of Interactive Team Cognition with visual framing theories and the notion of mental models and cognitive biases.

8.4.2 Production of Maps and Adaptation Tipping Points

After the theoretical and contextual phase, the visual maps were created in the Tygron Geodesign Platform. It is important to shortly highlight a few limitations of the Tygron Geodesign Platform. First and foremost, the sewage system and the surface water bodies are hydrologically simulated as compartments with a coupled inflow and outflow. It is of course not realistic for a complex sewage system to be assumed to be a homogenous. Besides, this also created the limitation of having only one sewage overflow, while the Huygenspark area contains multiple. While the results have been compared to the 3Di-model with a more complex sewage system (see Appendix A), this assumption increases the uncertainty range of the centimetres of water nuisance. Besides, the water level in the canals has been assumed to be constant. This limits reality, as during extreme rainfall events the canals might be able to account for some increase of level before issues occur. Their water level is also dependent on the water board, as the level of the canals is managed by dams. They could, therefore, decide to keep the water level lower before the expected rainfall event, which would decrease the negative effects. Lastly, the precipitation event is simulated as a continuous rainfall event over the entire project area. In reality, rainfall is heterogeneous through time, containing peaks and troughs, as well as spatial differences (due to the movement and variety of clouds). On certain locations, the water nuisance could thus be worse (e.g. if the event or peak happens mainly there) or even better dependent on the peak rainfall and movement of the clouds.

Besides, the data for these maps was through an interactive cycle of analysis of literature documents and engagement with actors, in which the chances and threats discussed by actors were central. While this caused the visual maps to be closely related to the reality of the municipal employees and made the reaction more realistic, this also resulted in a choice in how these four distinct frames look. The content and the visual representation of the colours and images were more heavily dependent on the researcher's choice and perspective of the limited amount of interviewees spoken to. The dependence on the researcher's choices on visual representation became more apparent during the translation of the textual adaptation tipping point to a spatial image. Limited research has previously translated adaptation tipping points to an image, with a lack of serious methodological steps to do this. Because of this, it is uncertain whether the choice to visualise adaptation tipping points this way (in Map 2) is the most suitable. Other decisions in the layout as well as the time component and increase in rainfall events could have been

made. Because this study does show that a visualisation of adaptation tipping points has the unique character of making consequences more concrete, this study recommends future research to bridge this textual and visual gap by researching and validating *how* the textual adaptation tipping points approach can be spatially visualised and whether this requires a broader definition. This study can, therefore, be seen as merely the first step, showing that spatial implications of adaptation tipping points could have potential.

At the beginning of the study, it has been decided to focus on the issue of extreme rainfall events. It is important to be aware that the issue of extreme rainfall events is merely one of the three themes (together with droughts and heat stress) within the climate change adaptation objectives of the Municipality of The Hague. Climate change adaptation is then again an objective within the large variety of objectives of the municipality. This raises the question to what extent the extreme rainfall objectives have priority or interest within the Municipality of The Hague and how the interpretation, reaction and perceived interaction on extreme rainfall events objectives relates to other municipal objectives. As this study shows that an individual's perception of what relates to them is important, other objectives (e.g. droughts) could have a stronger or different reaction. Because of this, it would be interesting to analyse how different frames of climate change adaptation (e.g. droughts, heat stress) improve or change the position of climate change adaptation on the overall municipal priority or objective list. This could show the value of maps, and more specifically the framing of adaptation tipping points, to induce a discussion on the (non-)importance of climate change adaptation and respective order of priorities.

It has been determined to focus on one adaptation tipping point to have a smaller number of visually contrasting frames. Because of this, the socio-political objectives of damages to electrical power boxes, damage to buildings and facilities, or more policy-oriented objectives have been neglected and are not visually presented to the municipal actors. This caused the threshold to be more dramatic, which, for example, caused a polarised reaction when the interviewee did not agree with the socio-political objective of inaccessibility of roads (in Map 2). This also showed that the selection of a singular threshold can have an opposite reaction of what is intended by the concept. This was even mentioned by six interviewees, which all suggested the extension of consequences to align with department interests, as shown in before in Figure 33. Because of this, it is recommended in future research to work with different thresholds from different policy domains. This would require an extra step in the methodology to define selection criteria to determine which objectives are seen as more important or a process of aligning the different objectives. This would also reflect the methodology of adaptation tipping points better and could extend and validate the results further. Visualising multiple thresholds: (1) can validate the results further on whether the reaction of actors, when the threshold does speak to them, creates a specific and action-orientated discussion compared to a climatic threshold (water nuisance), and (2) can show how different adaptation tipping points maps, which possibly each create a different interpretation or (polarised) reaction of an actor, would induce a discussion on the importance and respective order of priorities.

The visual maps were always accompanied by substantiating text in the same frame (in terms of focus on gains or losses and distant or near). It is, therefore, important to assess the implications of having congruent visual and textual frames on the measured interpretation and foreseen interaction. The majority of the studies on the interaction between textual frames and visual frames have shown that congruent textual and visual frames strengthen the framing effects on climate change opinions (e.g. Bolsen et al., 2019; Powell et al., 2015). Corresponding textual and visual frames benefit from both fields through the logical structure of the text and memorability of the visual, making both richer (Geise & Baden, 2015). As the text and visual both were framed similarly (in psychological distance and outcome), this might have created a stronger framing response and a stronger affective reaction than

would have happened without the accommodation of text. It might be interesting to analyse the effects of text in contrast to visual frames for climate maps, as there are only limited studies that vary the image and text content at the same time (Feldman & Hart, 2018; Powell et al., 2015). Especially since they are often accompanied by text or at least a subscript, for example, the Klimaatatlas Den Haag (Gemeente Den Haag, n.d.-b).

8.4.3 Semi-Structured Interviews

After the production phase, the maps were placed in order from issue to chance maps, becoming more and more abstract with each map: water nuisance, adaptation tipping points, spatial chances, and adaptation mainstreaming opportunities. This order was chosen to start from a comfortably known map, similar to the Den Haag Klimaatatlas, and make a step towards abstraction through each map. It was also the 'logical' order as to understand the chances you needed to be aware of the problems. Due to a limited number of employees, this order was the same for all interviewees. Therefore, it is important to note that this might have resulted in priming, which causes interviews to think about the previous map(s) or issues while answering the subsequent questions or analysing the subsequent maps. A different order of maps, therefore, could potentially lead to different reactions or a different constructed storyline. Priming should be taken into account in future studies, which is why it is recommended to differentiate between order.

It is also important to note that connecting an individual's mental model, cognitive biases, and how this would influence interaction is a complicated undertaking. Cognitive processes are still generally unknown and it is difficult to deduce whether the focus on the two cognitive biases that are accounted for are the source for the influence perceived in the semi-structured interviews. Someone's interpretation or perceived interaction undergoes a wide variety of processes in someone's mind. Cognitive biases and mental processes can amplify, dampen or counteract each other and happen at the same time, which makes it difficult to deduce whether the descriptive behaviour observed is caused by the cognitive theories described.

In addition, while the interviewees were asked how they foresee the maps being used in interaction, the question arises of how representative individual interviews are to measure the influence on (group) interaction. During group interaction, there are a wide variety of factors that influence the actual interaction or hinder the interviewees from doing their intended or foreseen interaction purpose(s). Factors such as the size of the project groups, time pressure during the interaction, status or power relations, and shared goals between team members are just a small subset of factors that could impact how the interviewees in an actual situation translate the maps to interaction. However, as all fourteen interviewees described their foreseen interaction with maps as a way to construct their story and this behaviour corresponds to the theoretical background, this story-telling intended interaction cannot be overlooked. It should be seen as a deeper understanding of the thought process of interpretation before the actual interaction.

Because of this, it is now important to couple this expected behaviour of story-telling to types of interaction, as this now seems separated. The observed story-telling can for example happen to ignite a discussion, substantiate an argument or show the options for adaptation mainstreaming. These are all different types of interaction. The next step, therefore, is to observe story-telling in practice, during actual group interaction. During this group interaction, it can be observed: (1) how maps are used to compete, confirm or integrate stories and (2) during which interaction or decision moments these maps are brought forward and for what interaction purpose. In addition, this interaction moment can also be combined with an interview afterwards, to have a better understanding of what their intended interaction

purpose was and what they actually did during the interaction. This could bridge the gap between the results of the foreseen interaction here and the actual interaction with visual maps.

Bridging this gap through future research should be extended towards other municipalities within the Netherlands. Currently, the findings are based on interviews within the Municipality of The Hague. The limited number of fourteen interviews within a specific case study raises the question of whether the results can be generalised to municipal employees and policy-makers. As discussed in the theory of Interactive Team Cognition, the organisational level can be of large influence on the individual's and team's level interaction and interpretation. It, therefore, might be that the Municipality of The Hague is more inclined towards certain interpretations or is used to applying maps solely for story-telling during the interaction. Doing research within other municipalities with different organisational discourses and focus points, as well as different working methods with maps, might result in a broader range of influences of maps on interaction. As the study does show that the two-way influence between an individual's mental model and visual framing is of importance in how the interviewee perceives a map to be applied in interaction, it will be interesting to expand this study towards other municipalities within the Netherlands. This can be done through observing actual interaction processes, but can also be through a survey or interviews. If the focus of the future research is on the dual influence between framing and interpretation, the future study can adopt a large-scale survey to distinguish the bias of the researcher and reach a larger group. Instead, if the focus is to explain the underlying principles more in-depth, this study has also shown that interviews allow understanding the complex relations between the underlying principles and stories around maps.

In addition, the semi-structured manner of the online interviews might subconsciously cause a bias in questions towards certain answers. Especially since the interviews were conducted by one individual researcher. In addition, the reaction of the interviewer towards one individual student can differentiate from reality, due to certain power relations and expectations. However, due to time restrictions, this could not have been avoided and a pilot interview has been conducted beforehand. In addition, the online interviews made nonverbal communication less explicit and possibly lacks the richness of the face-to-face interaction. The maps were also assessed through the screen, while during non-Covid interactions they would have been placed and interpreted on paper. Besides, during one interview the internet was quite poor, making it difficult to understand and ask follow-up questions. This could have influenced the reliability of the person's interpretation and understanding of the visual maps for this interview. While the online environment could not have been avoided, it would be advised to have future interviews face-to-face to avoid these issues. In addition, a second researcher should be present to avoid any bias or priming towards answers.

8.4.4 Inductive Thematic Analysis

After conducting the interviews, the interviews were analysed through an inductive thematic analysis. This inductive thematic analysis based on research data can lead to inconsistencies and a lack of coherence in data. In a study about mental models, it also cannot be ignored that the researcher's scope and interest could have a large impact on which data is seen as interesting and which is not. Besides, while the themes are created through rounds on data, an initial theoretical understanding and framework was already present, which might influence 'searching' for these types of results that could correspond or interest the theory. However, this study did do multiple rounds of coding and has followed known methodological steps to avoid these issues. Nevertheless, this study advises future researchers, as described in the critical reflection on theory, to have a well-defined theoretical framework from which an inductive thematic analysis can be done based on theory.

8.5 Implications of Results

Despite some of the outlined limitations of the theoretical framework and methodological choices, this study certainly still adds to new insights and subsequent implications. First and foremost, this study shows that the conceptual background and interaction between policymakers through visual climate tools is a complex process that cannot be limited to a one-way information flow. Individuals interpret the information through their personal mental model, which is altered through cognitive biases, after which this information either confirms, polarises or integrates their way of looking at the issue. This impacts how they will apply the tool and how they will construct their storyline around it. Therefore, the statement that adaptation tipping points, or climate tools in general, make the issue more easily understandable or manageable for policy-makers and, therefore, is a useful way to help adaptive decision-making does not necessarily hold. This deduction neglects the complex reality of an individual's interpretation and interaction processes.

While a producer, geographer or climate scientist can carefully choose the stylistic features and message of a visual through framing, this study shows that a simple map can be moulded and reframed to a broader story just as much as a carefully constructed one. This simultaneously also demonstrates that the potential of visual climate maps can be extensive: from having a discussion as to when water nuisance becomes an issue and where this would be (Map 1), building a shared social identity (Map 2), critically assessing why other areas are not chances (Map 3), becoming creative in mentioning measures (Map 4) or even constructing a discussion about the current working method and whether this is the correct one (Map 4).

However, all these potential discussions or foreseen interactions also suggests that a stand-alone visual map or geographical image might have limited reach. The maps need to be carried by a story of an individual or need to be brought forward into a discussion. By using words or speech, actors give meaning to the map and bring this meaning across to other colleagues or stakeholders as a story-support tool. This way, the maps merely seem to substantiate or concretise their story, which helps the story appeal to their imagination or mental image. Nevertheless, the story directions constructed around the maps might be difficult to predict in advance, as this study also suggests that it might be heavily dependent on the individual's reference point and intention before seeing the visual map. When maps did not align with the pre-existing perspective on the issue, actors either rejected the map or did not want to use the map anymore. This complicates the matter further, because especially during decision-making in uncertain conditions, maps based on scientific data should do more than confirm an individual's bias.

Nevertheless, this study does contribute to the growing body of visual framing studies by exploring the implications of framing the outcome (loss or gain) and the psychological distance on the interpretation and perceived interaction of municipal actors. In addition, the study shows that the combination of frames (by decreasing the distance in a loss frame) seems to give additional weight to the loss through concretely perceiving the negative effects.

8.6 Recommendations

In line with the implications and discussion points, this section gives an overview of the key future recommendations for practice and future research. These recommendations are a selection of the key recommendations mentioned throughout the chapter.

Recommendations for practice:

- It is important for municipal actors, as well as users of climate maps in general, to become more aware of their own interpretation and mental model, which causes climate tools and maps to have a non-uniform and non-objective meaning. Becoming more aware is the first step in breaking the cycle of confirming stories. This awareness helps in being more open to other discourses and perspectives, as well as becoming more open to the various details and other applications that climate tools might hold.

- Following the previous recommendation, it is key for municipal actors to critically assess whether increasing the number of climate maps and tools, as well as increasing their organisational focus on climate maps, is actually the solution to the interaction and decision-making issues that they encounter during policy-making processes in climate change adaptation.

Recommendations for future research:

- In line with the recommendations in practice, this study recommends a general increase in studies that focus on whether specific, as well as general, climate tools and maps improve the interaction and decision-making processes within municipal organisations. This is necessary to validate whether a certain climate tool indeed helps policy-makers and, if so, then in what way this is done.

- The story-telling influence of maps should be validated during actual group interaction. During this group interaction, it can be observed: (1) how maps are used to compete, confirm or integrate stories and (2) during which interaction or decision moments these maps are brought forward and for what interaction purpose. In addition, this interaction moment can also be combined with an interview afterwards, to have a better understanding of what their intended interaction purpose was and what they actually did during the interaction.

- Further research should focus on extending the amount of visually framed maps with a focus on the influence of fear framing and confirmation bias. This should show how a stronger affective response impacts the non-rational interpretation of the actors of climate change consequences.

- Future research should bridge the textual and visual gap of adaptation tipping points by researching and validating *how* the textual adaptation tipping points approach can be spatially visualised and what the implications of the visual adaptation tipping points are on the interpretation and interaction of the actors.

9

Conclusion

This chapter presents the main conclusions of this study which together answer the main research question. This study aimed to assess how visually framed extreme rainfall model results influence the interaction between municipal actors. This is explored through the assessment of adaptation tipping points, which is one way to visually frame extreme rainfall model results, and through the context of the Huygenspark neighbourhood and the municipal actors within the Municipality of The Hague.

To provide an answer to this question, the interaction within the Municipality of The Hague was first assessed to pinpoint any issues in interaction surrounding climate change adaptation that visual maps might overcome. To tackle climate change consequences, the Municipality of The Hague aims for an interdepartmental approach through adaptation mainstreaming (in Dutch called *'meekoppelkansen')*. The adaptation mainstreaming approach intends to implement climate measures in synergy with already planned infrastructural projects. Nevertheless, the interviews showed that municipal actors often remain focused on their own team's or department's interests and budget restrictions instead of the interdepartmental issue of climate change. This focus on the team's or department's interests lays at cross-purpose with the interdepartmental perspective necessary for adaptation mainstreaming and thus tackling climate change adaptation.

The extreme rainfall results have been framed by two contrasting frames: in terms of gains or losses and in terms of psychologically distant or near impacts. These two contrasting frames have resulted in the development of four visually framed extreme rainfall model results: water nuisance (Map 1), adaptation tipping points (Map 2), spatial opportunities (Map 3) and adaptation mainstreaming (Map 4). For the water nuisance map (Map 1), the model in the Tygron Geodesign Platform shows that especially the Stationsweg, the tunnel at the Rijswijkseweg and the tram tunnel underneath the train tracks will have water nuisance issues during extreme rainfall events. For the adaptation tipping points map (Map 2), the socio-political objective has been identified to focus on the critical urban infrastructure. The socio-political thresholds on critical infrastructure are focused on roads and is defined as: *"To maintain the accessibility of roads for cars and ambulances"*. This socio-political threshold corresponds to a climatic threshold of 30 centimetres of water on the streets. The model shows that for continuous rain showers of 40 mm/hour for the Stationsweg and the tram tunnel, and a rain shower of 30 mm/hour for the Rijswijkseweg tunnel, the threshold is already reached and these areas become inaccessible for cars and ambulances. Currently, the rain showers of 30 mm/hour and 40 mm/hour have a return period of approximately less than once every 10 years and once every 25 years respectively. This will increase to an unspecified low non-extreme return period and once every 13 years in the upper scenario of 2050 respectively. The main spatial opportunities in the Huygenspark are in the Oranjeplein and Huijgenspark, two open public space areas. The Huijgenspark area overlaps with the adaptation mainstreaming opportunity of the sewage works planned in 5 to 15 years.

The four maps were interpreted by fourteen municipal actors within the Municipality of The Hague. The study shows that visual framing indeed has an effect on the interpretation of municipal actors. For the distant loss map (Map 1), it was found that interviewees with limited detailed knowledge considered it difficult to understand whether the number of centimetres of water nuisance should be an issue or not. This is in contrast with the near-framed adaptation tipping points map (Map 2), which was said to make the issue more concrete. The adaptation tipping points map (Map 2) also caused actors to talk about the severity of the issue as well as taking concrete action, instead of merely signalising the overall extreme rainfall issue of Map 1. Besides, the gain-framed maps (Map 3 and Map 4) showed to create positive feelings in contrast to loss-framed maps (Map 1 and Map 2). While the interviewees focused on the severity or action necessary for the loss maps, the stories of the chance maps focused more on finding each other, bringing people together and bringing hope.

Besides the general influence of visual framing on the interviewee's interpretation, their interpretation is also determined by the pre-existing knowledge structures and ways of looking at the issue. This resulted in three distinct interpretations for the adaptation tipping points map (Map 2). In contrast to the general story of concrete action, Map 2 created a story of solidarity for the two urban planners. By coupling extreme rainfall events to a direct consequence outside the field of water management, they described Map 2 as being able to make it *our* issue that affects all the departments within the Municipality of The Hague. Another distinct interpretation is the one by the thematic experts compared to the non- or general thematic experts. The thematic experts had serious concerns about the correctness of the data and whether accessibility of roads was corresponding to reality. They preferred using the 'more objective' water nuisance map (Map 1) instead of the affective framing of adaptation tipping points (Map 2). The influence of pre-existing knowledge also became apparent for Map 3 and Map 4. It caused the spatial opportunity map (Map 3) to be rejected, as it disagreed with the notion of 'all areas are chances', while the adaptation mainstreaming map (Map 4) created a very positive reaction corresponding to their municipal approach.

While every map has its own main interpretation, most municipal actors emphasised that the maps should be combined to create an overall story. This story can be used during interaction to convince others, but it can also be to start a discussion or to weigh different options. The visual maps can, therefore, be seen as a *'story support tool'* for interaction. The interviewees pick and reframe the maps that align with the story they want to bring across. This way, extreme rainfall model results influence the interaction by helping people to engage with their story and translating their story into an image.

This study, therefore, shows that the influence of visually framed extreme rainfall model results on interaction could be diverse: from enabling a discussion on whether water nuisance is an issue to building a shared social identity. It demonstrates that predicting how maps will be interpreted, how stories will be constructed, and in which way they will be used is a complex undertaking. Individuals interpret the information through their personal mental model, which is altered through cognitive biases, after which this information either confirms, polarises or integrates their way of looking at the issue. It can, therefore, not be limited to a one-way information flow. Therefore, the study indicates that using adaptation tipping points, or climate tools in general, to make the issue more manageable for policy-makers does not necessarily have to be a useful way to help adaptive decision-making. While a producer, geographer or climate scientist can carefully choose the stylistic features and message of a visual through framing, this study shows that a simple map can be moulded and reframed to a broader story just as much as a carefully constructed one.

This study, therefore, provides a stepping stone for future research on the implications of model results for policy-makers and municipal actors in general. The study recommends validating and analysing the diverse story-telling possibilities of extreme rainfall maps during actual group interaction. It also recommends a general increase in studies that focus on whether specific, as well as general, climate tools and maps improve the interaction and decision-making processes within municipal organisations. This is necessary to validate whether a certain climate tool indeed helps policy-makers and in what way this helps. This is important, because while visually framed extreme rainfall model results might be able to say a thousand words, just a few words can change its story.

References

Adger, W. N., Brown, K., Nelson, D. R., Berkes, F., Eakin, H., Folke, C., Galvin, K., Gunderson, L., Goulden, M., O'Brien, K., Ruitenbeek, J., & Tompkins, E. L. (2011). Resilience implications of policy responses to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *2*(5), 757–766. https://doi.org/10.1002/WCC.133

Albers, R. A. W., Bosch, P. R., Blocken, B., van den Dobbelsteen, A. A. J. F., van Hove, L. W. A., Spit, T. J. M., van de Ven, F., van Hooff, T., & Rovers, V. (2015). Overview of challenges and achievements in the climate adaptation of cities and in the Climate Proof Cities program. In *Building and Environment* (Vol. 83, pp. 1–10). Elsevier Ltd. https://doi.org/10.1016/j.buildenv.2014.09.006

Bell, P. A., Greene, T. C., Fisher, J. D., & Baum, A. (2001). *Environmental Psychology* (5th ed., Vol. 24). Taylor & Francis Inc. https://doi.org/10.1146/annurev.ps.24.020173.002155

Bilandzic, H., Kalch, A., & Soentgen, J. (2017). Effects of Goal Framing and Emotions on Perceived Threat and Willingness to Sacrifice for Climate Change. *Science Communication*, *39*(4), 466–491. https://doi.org/10.1177/1075547017718553

Bolsen, T., Palm, R., & Kingsland, J. T. (2019). Counteracting Climate Science Politicization With Effective Frames and Imagery. *Science Communication*, *41*(2), 147–171. https://doi.org/10.1177/1075547019834565

Bos, J. J., Brown, R. R., & Farrelly, M. A. (2013). A design framework for creating social learning situations. *Global Environmental Change*, *23*(2), 398–412. https://doi.org/10.1016/j.gloenvcha.2012.12.003

Boyatzis, R. E. (1998). *Transforming qualitative information : thematic analysis and code development*. SAGE Publications, Inc.

Butler, J. R. A., Bohensky, E. L., Suadnya, W., Yanuartati, Y., Handayani, T., Habibi, P., Puspadi, K., Skewes, T. D., Wise, R. M., Suharto, I., Park, S. E., & Sutaryono, Y. (2016). Scenario planning to leap-frog the Sustainable Development Goals: An adaptation pathways approach. *Climate Risk Management*, *12*, 83–99. https://doi.org/10.1016/j.crm.2015.11.003

Chang, M. C., & Wu, C. C. (2015). The effect of message framing on pro-environmental behavior intentions: An information processing view. *British Food Journal*, *117*(1), 339–357. https://doi.org/10.1108/BFJ-09-2013-0247

Coles, D., Yu, D., Wilby, R. L., Green, D., & Herring, Z. (2017). Beyond 'flood hotspots': Modelling emergency service accessibility during flooding in York, UK. *Journal of Hydrology*, *546*, 419–436. https://doi.org/10.1016/j.jhydrol.2016.12.013

Convenant klimaatadaptief bouwen in Zuid-Holland. (2018). 1–3.

Cooke, N. J., Gorman, J. C., Myers, C. W., & Duran, J. L. (2013). Interactive Team Cognition. *Cognitive Science*, *37*, 255–285. https://doi.org/10.1111/cogs.12009

Dai, L., Wörner, R., & van Rijswick, H. F. M. W. (2018). Rainproof cities in the Netherlands: approaches in Dutch water governance to climate-adaptive urban planning. *International Journal of Water Resources Development*, *34*(4), 652–674. https://doi.org/10.1080/07900627.2017.1372273

de Boer, J., Wardekker, J. A., & van der Sluijs, J. P. (2010). Frame-based guide to situated decision-making on climate change. *Global Environmental Change*, *20*, 502–510. https://doi.org/10.1016/j.gloenvcha.2010.03.003

de Jonge, A. (2021). *Is this resilient enough? Including users' acceptance levels into the critical infrastructure resilience assessment*.

Deltares. (2019). *Resultaten CIrcle Workshop 24 januari 2019 100 Resilient Cities Den Haag*.

Dewulf, A., & Termeer, C. (2015). Governing the future? The potential of adaptive delta management to contribute to governance capabilities for dealing with the wicked problem of climate change adaptation. *Journal of Water and Climate Change*, *6*(4), 759–771. https://doi.org/10.2166/wcc.2015.117

Edwards, M. R. (2005). Organizational identification: A conceptual and operational review. *International Journal of Management Reviews*, *7*(4), 207–230.

Eikelboom, T., & Janssen, R. (2015). Comparison of Geodesign Tools to Communicate Stakeholder Values. *Group Decision and Negotiation*, *24*(6), 1065–1087. https://doi.org/10.1007/s10726-015-9429-7

Eriksen, S., Aldunce, P., Bahinipati, C. S., Martins, R. D. A., Molefe, J. I., Nhemachena, C., O'Brien, K., Olorunfemi, F., Park, J., Sygna, L., & Ulsrud, K. (2011). When not every response to climate change is a good one: Identifying principles for sustainable adaptation. In *Climate and Development* (Vol. 3, Issue 1, pp. 7–20). https://doi.org/10.3763/cdev.2010.0060

Feldman, L., & Hart, P. S. (2018). Is There Any Hope? How Climate Change News Imagery and Text Influence Audience Emotions and Support for Climate Mitigation Policies. *Risk Analysis*, *38*(3), 585–602. https://doi.org/10.1111/risa.12868

Geise, S., & Baden, C. (2015). Putting the image back into the frame: Modeling the linkage between visual communication and frame-processing theory. *Communication Theory*, *25*(1), 46–69. https://doi.org/10.1111/comt.12048

Gemeente Den Haag. (n.d.-a). *Klimaatatlas*. Retrieved November 3, 2020, from https://denhaag.klimaatatlas.net/

Gemeente Den Haag. (n.d.-b). *Den Haag Klimaatatlas*. Retrieved January 12, 2021, from https://denhaag.klimaatatlas.net/

Gemeente Den Haag. (n.d.-c). *Wijkprofielen - Bevolking - 18 Huygenspark*. Retrieved June 25, 2021, from https://denhaag.incijfers.nl/dashboard/wijkprofielen/bevolking/

Uitvoeringsplan: Klimaatbestendig Den Haag, (2012) (testimony of Gemeente Den Haag).

Gemeente Den Haag. (2016). *Toekomstbestendig Haags water!*

Gemeente Den Haag. (2018). *De bedrijfsvoering van de gemeente*. https://www.denhaag.nl/nl/bestuur-en-organisatie/werken-bij-de-gemeente/de-bedrijfsvoering-van-de-gemeente.htm

Handboek Openbare Ruimte, (2020) (testimony of Gemeente Den Haag).

Gemeente Den Haag. (2020a, July 8). *De gemeentelijke organisatie*. https://www.denhaag.nl/nl/bestuur-en-organisatie/gemeentelijke-organisatie/de-gemeentelijke-organisatie.htm

Gemeente Den Haag. (2020b). *Concept Integraal Gemeentelijk Rioleringsplan 2021-2025*.

Gemeente Den Haag, & Resilient The Hague. (2019). *The Hague Resilience Strategy*. www.denhaag.buurtmonitor.nl

Gemeente Terneuzen. (2019). *Water- en Rioleringsplan 2019-2023*.

Gersonius, B., Nasruddin, F., Ashley, R., Jeuken, A., Pathirana, A., & Zevenbergen, C. (2012). Developing the evidence base for mainstreaming adaptation of stormwater systems to climate change. *Water Research*, *46*, 6824–6835. https://doi.org/10.1016/j.watres.2012.03.060

Gommeh, E., Dijstelbloem, H., & Metze, T. (2020). Visual discourse coalitions: visualization and discourse formation in controversies over shale gas development. *Journal of Environmental Policy and Planning*, *3*, 363–380. https://doi.org/10.1080/1523908X.2020.1823208

Gorman, J. C., & Cooke, N. J. (2011). Changes in Team Cognition After a Retention Interval: The Benefits of Mixing It Up. *Journal of Experimental Psychology: Applied*, *17*(4), 303–319. https://doi.org/10.1037/a0025149

Gorman, J. C., Cooke, N. J., & Winner, J. L. (2006). Measuring team situation awareness in decentralized command and control environments. *Ergonomics*, *49*(12–13), 1312–1325. https://doi.org/10.1080/00140130600612788

Groves, K. S., & Vance, C. M. (2015). Linear and nonlinear thinking: A multidimensional model and measure. *Journal of Creative Behavior*, *49*(2), 111–136. https://doi.org/10.1002/jocb.60

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change*, *23*(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Hajer, M. A. (1997). *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford University Press. https://doi.org/10.1093/019829333X.001.0001

Hoogheemraadschap van Delfland. (2021, July 16). *Hoogwaterstand Limburg: wat betekent dit voor Delfland? - Delfland*. https://www.hhdelfland.nl/actueel/nieuws/2021/juli/hoogwaterstand-limburg-betekent-delfland/

Hornsey, M. J., Blackwood, L., & O'Brien, A. (2005). Speaking for others: The pros and cons of group advocates using collectives language. *Group Processes and Intergroup Relations*, *8*(3 SPEC. ISS.), 245–257. https://doi.org/10.1177/1368430205053941

Houthuijs, P. (2021, July 15). *Domino-effect van regenwater op komst, hoe goed zijn we beschermd? | NOS*. https://nos.nl/collectie/13869/artikel/2389497-domino-effect-van-regenwater-op-komst-hoe-goed-zijn-we-beschermd

IPCC. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.

Jacobson, S. K., Morales, N. A., Chen, B., Soodeen, R., Moulton, M. P., & Jain, E. (2019). Love or Loss: Effective message framing to promote environmental conservation. *Applied Environmental Education and Communication*, *18*(3), 252–265. https://doi.org/10.1080/1533015X.2018.1456380

Johnson, B. T., & Eagly, A. H. (1989). Effects of Involvement on Persuasion: A Meta-Analysis. *Psychological Bulletin*, *106*(2), 290–314.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias. *Journal of Economic Perspectives*, *5*(1), 193–206.

Kahneman, D., & Tversky, A. (1979). *Prospect Theory: An Analysis of Decision under Risk* (Vol. 47, Issue 2). https://about.jstor.org/terms

Kahneman, D., & Tversky, A. (1996). On the Reality of Cognitive Illusions. *Psychological Review*, *103*(3), 582–591.

KNMI. (2006). *KNMI Climate Change Scenarios 2006 for the Netherlands*. www.knmi.nl
KNMI. (2015a). *KNMI'14 klimaatscenario's voor Nederland*. 1–34.
KNMI. (2015b). KNMI'14-klimaatscenario's voor Nederland; Leidraad voor professionals in klimaatadaptatie. *KNMI*.
Koetse, M. J., & Rietveld, P. (2009). The impact of climate change and weather on transport: An overview of empirical findings. *Transportation Research Part D: Transport and Environment*, *14*(3), 205–221. https://doi.org/10.1016/j.trd.2008.12.004
Koukoui, N., Gersonius, B., Schot, P. P., & van Herk, S. (2015). Adaptation tipping points and opportunities for urban flood risk management. *Journal of Water and Climate Change*, *6*(4), 695–710. https://doi.org/10.2166/wcc.2015.093
Krijger, T. (2018). *City index: Ranking van hoofdsteden in Nederland op basis van risico's ten opzichte van extreme neerslag*.
Kunda, Z. (1990). The Case for Motivated Reasoning. *Psychological Bulletin*, *108*(3), 480–498.
Kurganov, A., & Petrova, G. (2007). A second-order well-balanced positivity preserving central-upwind scheme for the Saint-Venant system. *Communications in Mathematical Sciences*, *5*(1), 133–160. https://doi.org/10.4310/CMS.2007.v5.n1.a6
Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P. M., Hoogvliet, M. M. C., Jeuken, A. B. M., van der Krogt, R. A. A., van Oostrom, N. G. C., Schelfhout, H. A., van Velzen, E. H., van Waveren, H., & de Wit, M. J. M. (2010). Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(5), 729–740. https://doi.org/10.1002/wcc.64
Kwakkel, J. H., & Haasnoot, M. (2019). Supporting DMDU: A Taxonomy of Approaches and Tools. In *Decision Making under Deep Uncertainty* (pp. 355–374). Springer International Publishing. https://doi.org/10.1007/978-3-030-05252-2_15
Lawrence, J., & Haasnoot, M. (2017). What it took to catalyse uptake of dynamic adaptive pathways planning to address climate change uncertainty. *Environmental Science and Policy*, *68*, 47–57. https://doi.org/10.1016/j.envsci.2016.12.003
Leiserowitz, A. A. (2005). American risk perceptions: Is climate change dangerous? *Risk Analysis*, *25*(6), 1433–1442. https://doi.org/10.1111/j.1540-6261.2005.00690.x
Lenderink, G., & van Meijgaard, E. (2008). Increase in hourly precipitation extremes beyond expectations from temperature changes. *Nature Geoscience*, *1*(8), 511–514. https://doi.org/10.1038/ngeo262
Lhomme, S., Serre, D., Diab, Y., & Laganier, R. (2013). Analyzing resilience of urban networks: A preliminary step towards more flood resilient cities. *Natural Hazards and Earth System Science*, *13*(2), 221–230. https://doi.org/10.5194/nhess-13-221-2013
Lin, B. B., Capon, T., Langston, A., Taylor, B., Wise, R., Williams, R., & Lazarow, N. (2017). Adaptation Pathways in Coastal Case Studies: Lessons Learned and Future Directions. *Coastal Management*, *45*(5), 384–405. https://doi.org/10.1080/08920753.2017.1349564
Liu, L. A., & Dale, C. (2009). Using Mental Models to Study Cross-Cultural Interactions. In C. Nakata (Ed.), *Beyond Hofstede: Culture Frameworks for Global Marketing and Management* (pp. 222–244). https://www.researchgate.net/publication/267098979
Manocha, N., & Babovic, V. (2017). Development and valuation of adaptation pathways for storm water management infrastructure. *Environmental Science and Policy*, *77*, 86–97. https://doi.org/10.1016/j.envsci.2017.08.001
Ministerie van Infrastructuur en Milieu, & Ministerie van Economische Zaken. (2017). *Deltaprogramma 2018*. www.deltacommissaris.nl.
Ministerie van Infrastructuur en Waterstaat, STOWA, & Stichting RIONED. (2020). *Standaarden voor de stresstest wateroverlast*.
Morseletto, P. (2017). Analysing the influence of visualisations in global environmental governance. *Environmental Science and Policy*, *78*, 40–48. https://doi.org/10.1016/j.envsci.2017.08.021
Moser, S. C. (2010). Communicating climate change: history, challenges, process and future directions. *WIREs Climate Change*, *1*(1). https://doi.org/10.1002/wcc.11
Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, *2*(2), 175–220. https://doi.org/10.1037/1089-2680.2.2.175
Nisbet, M. (2009). Communicating climate change: Why frames matter for public engagement. *Environment*, *51*(2), 12–23. https://doi.org/10.3200/ENVT.51.2.12-23
Nisbet, M. C., & Mooney, C. (2007). Framing science. In *Science* (Vol. 316, Issue 5821, pp. 56–56). https://doi.org/10.1126/science.1142030
Nisbet, M. C., & Scheufele, D. A. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, *96*(10), 1767–1778. https://doi.org/10.3732/ajb.0900041

OECD. (2014). *Water governance in the Netherlands: Fit for the future?*
Offermans, A. (n.d.). *Learning from the past The interaction of the social system and the water system in the Netherlands*.
O'Neill, S. J. (2013). Image matters: Climate change imagery in US, UK and Australian newspapers. *Geoforum*, *49*, 10–19. https://doi.org/10.1016/j.geoforum.2013.04.030
O'Neill, S. J., & Smith, N. (2014). Climate change and visual imagery. In *Wiley Interdisciplinary Reviews: Climate Change* (Vol. 5, Issue 1, pp. 73–87). Wiley-Blackwell. https://doi.org/10.1002/wcc.249
PDOK. (2020). *Dataset: Stedelijk Water (Riolering)*. https://geodata.nationaalgeoregister.nl/rioned/gwsw/wfs/v1_0?&request=GetCapabilities&service=WFS
Powell, T. E., Boomgaarden, H. G., de Swert, K., & de Vreese, C. H. (2015). A Clearer Picture: The Contribution of Visuals and Text to Framing Effects. *Journal of Communication*, *65*(6), 997–1017. https://doi.org/10.1111/jcom.12184
Programma van Eisen. (2019). 1–17.
Ramm, T. D., Watson, C. S., & White, C. J. (2018). Describing adaptation tipping points in coastal flood risk management. *Computers, Environment and Urban Systems*, *69*, 74–86. https://doi.org/10.1016/j.compenvurbsys.2018.01.002
Räthzel, N., & Uzzell, D. (2009). Changing relations in global environmental change. *Global Environmental Change*, *19*(3), 326–335. https://doi.org/10.1016/j.gloenvcha.2009.05.001
Rodriguez, L., & Dimitrova, D. v. (2011). The levels of visual framing. *Journal of Visual Literacy*, *30*(1), 48–65. https://doi.org/10.1080/23796529.2011.11674684
Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In *Social Psychophysiology* (pp. 153–176). https://www.researchgate.net/publication/229068371
Rose, G. (2007). *Visual methodologies: An Introduction to the Interpretation of Visual Materials*. SAGE publications.
Rose, G. (2016). *Visual Methodologies: An Introduction to Researching with Visual Materials* (4th ed.). SAGE Publications.
RTL Nieuws. (2021, July 16). *Strijd tegen water verloren: "Dertig jaar geleden hadden we keuze, nu niet meer" | RTL Nieuws*. https://www.rtlnieuws.nl/nieuws/buitenland/artikel/5242157/overstromingen-toekomst-klimaatverandering-vaker-zien
Sayers, P., Li, Y., Galloway, G., Penning-Rowesell, E., Shen, F., Wen, K., Chen, Y., & le Quesne, T. (2013). *Flood Risk Management: A Strategic Approach*. UNESCO.
Scannell, L., & Gifford, R. (2013). Personally Relevant Climate Change: The Role of Place Attachment and Local Versus Global Message Framing in Engagement. *Environment and Behavior*, 1–26. https://doi.org/10.1177/0013916511421196
Schoenefeld, J. J., & McCauley, M. R. (2016). Local is not always better: the impact of climate information on values, behavior and policy support. *Journal of Environmental Studies and Sciences*, *6*(4), 724–732. https://doi.org/10.1007/s13412-015-0288-y
Schuldt, J. P., McComas, K. A., & Byrne, S. E. (2016). Communicating about ocean health: Theoretical and practical considerations. In *Philosophical Transactions of the Royal Society B: Biological Sciences* (Vol. 371, Issue 1689). Royal Society of London. https://doi.org/10.1098/rstb.2015.0214
Spence, A., & Pidgeon, N. (2010). Framing and communicating climate change: The effects of distance and outcome frame manipulations. *Global Environmental Change*, *20*(4), 656–667. https://doi.org/10.1016/j.gloenvcha.2010.07.002
Stanton, M. C. B., & Roelich, K. (2021). Decision making under deep uncertainties: A review of the applicability of methods in practice. *Technological Forecasting and Social Change*, *171*, 120939. https://doi.org/10.1016/J.TECHFORE.2021.120939
STOWA. (2018). *Neerslagstatistieken voor korte duren : actualisatie 2018*.
Trope, Y., & Liberman, N. (2010). Construal-Level Theory of Psychological Distance. *Psychological Review*, *117*(2), 440–463. https://doi.org/10.1037/a0018963
Turnhout, E., Tuinstra, W., & Halffman, W. (2019). *Environmental Expertise: Connecting Science, Policy, and Society*. Cambridge University Press. https://doi.org/10.1017/9781316162514
Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science*, *185*(4157), 1124–1131. https://doi.org/10.1126/SCIENCE.185.4157.1124
Tversky, A., & Kahneman, D. (1992). Advances in Prospect Theory: Cumulative Representation of Uncertainty. In *Journal of Risk and Uncertainty* (Vol. 5).
Tygron Geodesign Platform. (n.d.). *Tygron Features*. Retrieved November 3, 2020, from https://www.tygron.com/nl/features-2/

van Beek, L., Metze, T., Kunseler, E., Huitzing, H., de Blois, F., & Wardekker, A. (2020). Environmental visualizations: Framing and reframing between science, policy and society. *Environmental Science and Policy*, *114*, 497–505. https://doi.org/10.1016/j.envsci.2020.09.011

van Dick, R. (1992). Identification in organizational contexts: linking theory and research from social and organizational psychology. *Meyer and International Journal of Management Reviews*, *3*(4), 265–283.

Wang, S., Hurlstone, M. J., Leviston, Z., Walker, I., & Lawrence, C. (2021). Construal-level theory and psychological distancing: Implications for grand environmental challenges. *One Earth*, *4*(4), 482–486. https://doi.org/10.1016/j.oneear.2021.03.009

Wardekker, A., & Lorenz, S. (2019). The visual framing of climate change impacts and adaptation in the IPCC assessment reports. *Climatic Change*, *156*, 273–292. https://doi.org/10.1007/s10584-019-02522-6

Werners, S. E., Pfenninger, S., van Slobbe, E., Haasnoot, M., Kwakkel, J. H., & Swart, R. J. (2013). Thresholds, tipping and turning points for sustainability under climate change. In *Current Opinion in Environmental Sustainability* (Vol. 5, Issues 3–4, pp. 334–340). https://doi.org/10.1016/j.cosust.2013.06.005

Werners, S., Swart, R., van Slobbe, E., Bölscher, T., Pfenninger, S., Trombi, G., & Moriondo, M. (2015). Turning points in climate change adaptation. *Ecology and Society*, *20*(4). http://www.adaptgov.com/

Zahran, S., Brody, S. D., Grover, H., & Vedlitz, A. (2006). Climate change vulnerability and policy support. *Society and Natural Resources*, *19*(9), 771–789. https://doi.org/10.1080/08941920600835528

Zandvoort, M., Kooijmans, N., Kirshen, P., & van den Brink, A. (2019). Designing with pathways: A spatial design approach for adaptive and sustainable landscapes. *Sustainability (Switzerland)*, *11*(3). https://doi.org/10.3390/su11030565

Zwickle, A., & Wilson, R. S. (2013). Construing risk: Implications for risk communication. In J. Arvai & L. Rivers III (Eds.), *Effective Risk Communication* (1st ed.). Routledge. https://www.researchgate.net/publication/267026110

Appendices

Appendix A

Tygron Geodesign Platform Set-Up

To assess the consequences and chances of extreme rainfall events, the Tygron Geodesign Platform has been applied. The Tygron Geodesign Platform is a cloud-based software package that allows users to generate a three-dimensional model of a specified project area. Due to the Education License, this is a maximum area of 1 km^2. The project area fully consists of the Huygenspark neighbourhood, as shown in Figure 36. Within the Huygenspark, a grid cell size of 1.3 x 1.3 metres is used to comply with sufficient bathymetry accuracy. After deciding on the project area, the Tygron Geodesign Platform creates a three-dimensional visualisation of the environment, including constructions.

Figure 36: The project boundaries, as shown in the red square of 1,000 by 1,000 metres, compared to the Huygenspark neighbourhood boundaries.

To provide these insights within the specified area, the Tygron Geodesign Platform is connected to (open) geodata, e.g. Base Registers in the Netherlands and Open Street Maps worldwide, as described in Table 9. In addition, users can import geodata themselves, as either vector data, e.g. Web Feature Services (WFS) and GeoJSON files, or as raster data through Web Map Services (WMS) or a GeoTiff Overlay. This geodata is used as an input for various hydrological, administrative, and environmental equations and simulations.

Table 5: Data sources coupled to the Tygron Geodesign Platform

Name	Uploader	Description	Connection Source or More Information
BAG	PDOK	The type and location of buildings and the residential units in them.	http://geodata.nationaalgeoregister.nl/bag/wfs
BRO	PDOK	Detailed information on the subsurface type and characteristics.	https://geodata.nationaalgeoregister.nl/bzk/bro-bodemkaart/wms/v1_0
BGT	PDOK	The topography of the Netherlands, including roads, parks, trees, water surfaces and street objects.	https://www.kadaster.nl/bgt
BRP	Nationaal Georegister	Location of agricultural plots and type of cultivated crops.	http://geodata.nationaalgeoregister.nl/brpgewaspercelen/wfs
CBS	PDOK	The geometrical division of neighbourhoods and their statistical data.	http://geodata.nationaalgeoregister.nl/wijkenbuurten2016/wfs
World Imaginary	ESRI	Satellite data used as the base map for the three-dimensional world	https://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/0

Ocean Basemap	ESRI	Map with ocean data, including locations of water bodies and their names.	https://services.arcgisonline.com/arcgis/rest/services/Ocean_Basemap/MapServer
DTM	ESRI	Terrain heights of the bare ground.	http://www.arcgis.com/home/item.html?id=58a541efc59545e6b7137f961d7de883
AHN	Nationaal Georegister	The terrain height including buildings, trees and other objects.	https://www.ahn.nl/
Top10NL	Tygron/PDOK	Topographical dataset, used as an addition to the BGT data.	https://www.kadaster.nl/-/top10nl
NWB	PDOK	Detailed information about road infrastructure	https://www.rijkswaterstaat.nl/zakelijk/zakendoen-met-rijkswaterstaat/werkwijzen/werkwijze-in-gww/data-eisen-rijkswaterstaatcontracten/nationaal-wegenbestand.aspx
BRK	Nationaal Georegister	To determine the location of parcels.	https://geodata.nationaalgeoregister.nl/kadastralekaart/wfs/v4_0
Risicokaart	Risicokaart.nl	Shows the risks in a neighbourhood, including vulnerable buildings.	https://www.rijkswaterstaat.nl/zakelijk/zakendoen-met-rijkswaterstaat/werkwijzen/werkwijze-in-gww/data-eisen-rijkswaterstaatcontracten/nationaal-wegenbestand.aspx
OSM	The instance overpass of API	The topography of the world and attribute information.	https://www.openstreetmap.org/
R.W.A.-data	PDOK	Several datasets from Regional Water Authorities aligned with the Information Model Water	http://www.nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/40840197-0478-432b-8c76-e99c4da9203f?tab=general

To understand which geo data is used and how this geo data is translated into climate visualisations, this Annex provides insight into the equations and simulations applied in the Tygron Geodesign Platform. This is done by first explaining the overarching formulae in the Water Module (Section A.1), followed by a specific description of the Rainfall Overlay within this Water Module (Section A.2). The Annex is finalised by discussing the validation of the model simulations (Section A.3).

A.1 Water Module

To be able to perform calculations on the project area, the Tygron Geodesign Platform draws a multitude of two-dimensional grid-based layers over the three-dimensional world, called Overlays. The Overlays specialised in water management focus on rain-related, flooding-related, and groundwater-related simulations. Each of these Overlays is connected to the Water Module, a hydrological calculation model of the Tygron Geodesign Platform. The Water Module simulates the two-dimensional movement of shallow water between the grid cells. This is done by dividing the total simulation time into discrete time steps. During each time step, a quantity of water and specific hydrological parameters is identified for each grid cell, from which the flow of water is driven by imbalances in the water surface elevation and the current flow direction between the adjacent cells. This behaviour is described by the formulae of Kurganov and Petrova (2007), which are based on the two-dimensional Saint Venant equations.

A.2 Rainfall Overlay

To visualise extreme rainfall events, the Rainfall Overlay within the Water Module has been implemented. Within the Rainfall Overlay, the rainfall and runoff within an urban area are simulated through multiple coupled sewer and surface water reservoirs. The graphical representation of the model visualisation of the Rainfall Overlay is shown in Figure 37. The water flows, as shown in Figure 37, are based on two main sources of geo files:

3. The sources initially connected to the Tygron Geodesign Platform, as elaborated on in Table 9.
4. The imported WFS file of the '*Stedelijk Water Riolering*', which contains the location of the weirs, culverts, and sewage overflows, and sewage areas (PDOK, 2020).

When setting up the Rainfall Overlay, three main steps can be characterised: defining the rainfall and shallow groundwater flows, setting up the water system, including hydraulic structures, (ground)water level, sewer and inundation areas, and defining the hydraulic coefficients. Each of these steps will be further elaborated on below.

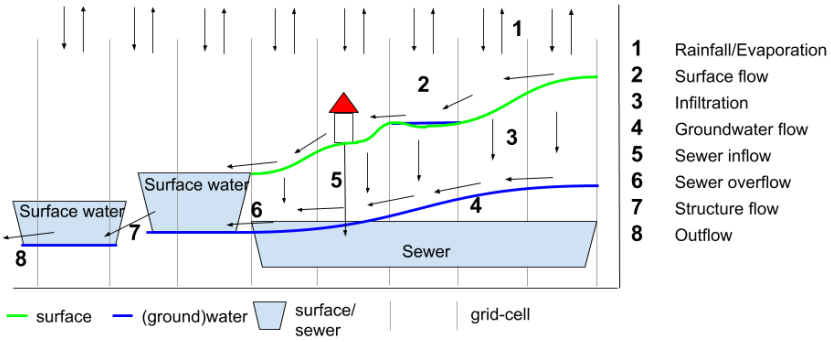

Figure 37: Graphical representations of the Rainfall Overlay

A.2.1 Defining the Rainfall and Shallow Groundwater Flow

In the first step of the Rainfall Overlay, it has to be determined what type of rainfall and evaporation input is applied (linear or custom), and what kind of simulation time, calculation area and groundwater mode are chosen. For all simulations, the calculation area is depicted to be the whole project area (1 km^2), while the evaporation is depicted to be linear and uniform with 1.5 mm/day. For the groundwater mode, only infiltration is accounted for. This means that water can infiltrate into the unsaturated zone, but that there is no underground flow or underground evaporation present. This is chosen, as the underground flow and evaporation have a neglectable impact when focusing on rainfall events and leaving it out adds to the performance of the calculation setup. Furthermore, the rainfall amount during the hour of rain differs per rain shower scenario. Six rain showers of 10 to 80 mm/hour have been simulated with in-between steps of 10 mm. The dry period of 60 minutes after the rainfall event remains equal for each scenario, making the total simulation time 120 minutes.

A.2.2 Setting up the Water System

The second step in the Rainfall Overlay is defining the water system, including the water level areas, groundwater level areas, sewer areas, inundation areas and hydraulic structures. First, for the water level areas, information of the municipality on the actual groundwater levels per measurement station (Gemeente Den Haag, 2020) were compared and discussed with A. Hagen, policy advisor for the Team Sewage System, Roads and Subsurface at the Service Urban Management, (A. Hagen, personal communication, January 28, 2021) for the Huygenspark. Based on this discussion, and the desired accuracy level for the model, it had been decided to specify two water level areas: one water level area of -0.40 metres nearby water bodies, e.g. canals, and another water level area of -0.80 metres outside this area, with the Amsterdam Ordnance Datum (NAP) as the reference datum, see Figure 38. These water level areas also consider that the Huygenspark is located in a lowland system (*'boezemgebied'*), in which all waterways are openly connected and have the same water level of -0.40 metres (Gemeente Den Haag, 2016).

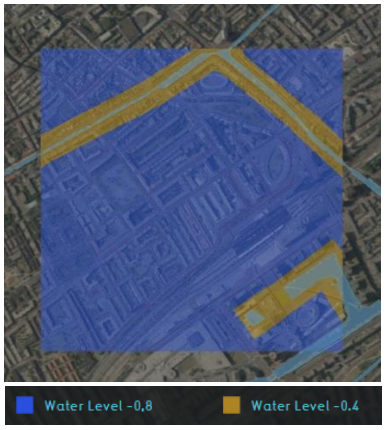

Figure 38: Water Level Areas in the Project Area

Figure 39: Sewer Areas in the Project Area

The next phase in setting up the water system of the Rainfall Overlay requires the identification of the initial groundwater depth at the start of the simulation and the inundation areas. As the simulation focuses on (extreme) rainfall events, no initial groundwater depth is selected, which causes the water levels of the water level areas to be used to initialise the groundwater levels. In addition, inundation areas allow for initial placement of water on the surface, for example when an area is already seriously flooded, or an area can be used as a water buffer. As this is not the case in the Huygenspark, no inundation area is present in the project area.

In addition, sewer areas are present in the Huygenspark. In the Tygron Geodesign Platform, sewer areas, or districts, are represented as a single uniform water reservoir, with one storage value [m]. Sewer pipes conceptually exist at all grid cells in the model where a sewer area intersects with a sewered construction. Whether a construction is connected to the sewer is based on Boolean units (0 or 1), and is set default to 1 for all buildings, constructions and roads imported from the *'Basisregistratie Adressen en Gebouwen*' (BAG) and *'Basisregistratie Grootschalig Topografie'* (BGT). The boundaries of the sewer areas are imported from the WFS-file of the '*Stedelijk Water Riolering*', and more specifically the Layer '*Beheergegevens Gebied*', which shows the project area to be divided into two sewer areas: Centrum and Laakhaven, as shown in Figure 39.

As shown in Figure 37, the sewer water reservoirs are depicted by an inflow and outflow of water. The inflow into these sewage areas is through buildings connected to the sewer, e.g. roads and houses, on which water is located, whereas the sewage outflow is either pumped to an area outside the project area (pump capacity) or through a sewer overflow into the surface water (hydraulic structure). Water can flow into the sewage until the sewage is filled to its capacity. The sewage capacity for Centrum and Laakhaven is 18.3 mm and 15.3 mm, respectively (Gemeente Den Haag, 2015). The total sewage storage volume is, therefore, the sum of all grid cells connected to the sewer, multiplied by the grid cell size and the mentioned sewer storage. The sewage outflow is determined by the fixed pump capacity [m^3/s] to an area outside the project. The pump overcapacity in The Hague is 0.70 mm/hour (Gemeente Den Haag, 2015). The sewage area in the project is 767,477 m^2 and 232,523 m^2 for Centrum and Laakhaven, respectively, which results in a pump capacity of 0.14923 m^3/s and 0.04521 m^3/s for Centrum and Laakhaven, respectively.

To conclude the first step of building the water system, hydraulic structures have to be implemented and imported into the project area, including the sewer overflows. Per sewage area, one sewage overflow can be present. Sewage overflows are point-based constructions from which water is removed from the sewage system into the surface water. In this case, the excess sewage water flows into the canals from the allocated point source. Currently, the Centrum sewage area located within the project

has two sewage overflows, as can be seen in Figure 40. However, in the Tygron Geodesign Platform, a sewage area can only have one overflow per sewage area. Because of this, it has been decided, together with Arthur Hagen (A. Hagen, personal communication, January 28, 2021), that appointing the sewage overflow furthest away from the water pump station will give the most realistic image, as shown as a red dot in Figure 21. In addition, the other sewage overflows are also smaller in scale, which makes it more realistic to neglect them instead of the sewage overflow in Figure 40.

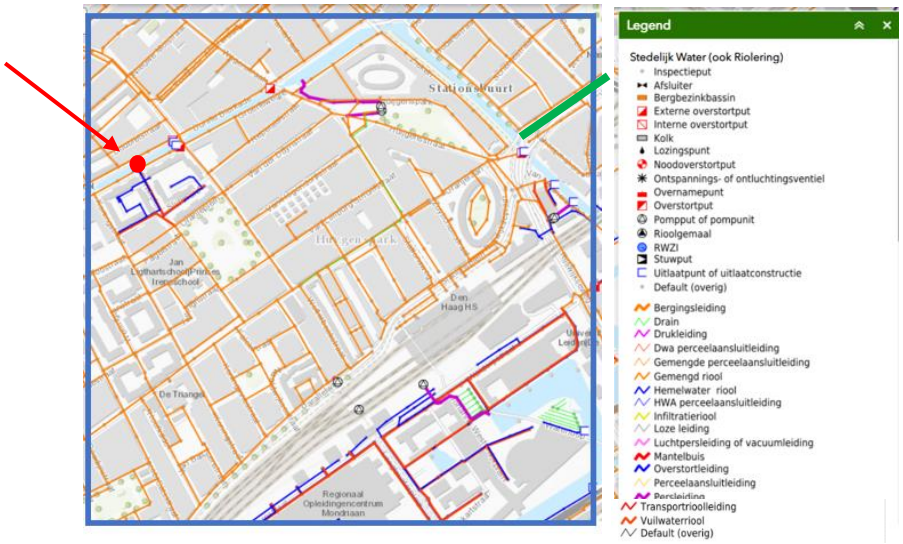

Figure 40: Location of Sewage Overflow, indicated by the red dot, and a culvert, indicated by the green line.

The amount of water flowing into the canals from the sewage overflow is determined by the maximum overflow speed and the sewage overflow threshold. Water will flow out of the overflow construction when the sewage water height exceeds the sewer overflow threshold. The threshold is determined to be a fraction of 1/3 of the sewer storage, while the maximum sewage overflow speed is fixed at 2.0 m^3/s. The maximum overflow speed is based on a simulation of an unrealistic extreme rainfall event (200 mm/hour) in the 3Di-model of A. de Jonge (A. de Jonge, personal communication, February 22, 2021), which showed a maximum overflow speed of 2.0 m^3/s. In addition, the height from which water exits the sewage system, the sewage overflow height, is set at the equal height of the open water level, which is -0.8 metres.

Other hydraulic structures present in the Tygron Geodesign Platform are weirs and culverts. Weirs are small dams located in water bodies that allow water to flow from a higher water level to a lower water level. In the water bodies of the Huygenspark, no weirs are present, while there is one culvert present in the project area, as shown in green in Figure 40. This culvert is ending outside the project area, somewhere in the Rivierenbuurt. The Tygron Geodesign Platform, however, does not accept culverts to continue and end outside the selected project area. As has been discussed with Arthur Hagen (A. Hagen, personal communication, January 28, 2021), the culvert is of insignificant impact, which is why the culvert is neglected in the model.

Furthermore, the Tygron Geodesign Platform offers the possibility to implement drainage structures and pumps. Drainage systems provide a connection between the underground and nearby waterways, whereas pumps move water from one water body to another, against its natural flow. As some areas within the Huygenspark have flooded regularly in the past, pumps have been installed that transport water into the sewage, as shown in Figure 40 as *'pompput'*. However, in the Tygron Geodesign Platform, a pump does not transport water from a non-water body into the sewage. Because the locations of the sewage pumps are not within water bodies, for example, the tunnel near the station contains a

pump, and the water is transported into the sewage instead of another water body, implementing a pump construction in Tygron did not overcome the issue.

A.2.3 Defining the Hydraulic Coefficients

The last step in the Rainfall Overlay is defining the hydraulic coefficients of the surface, sub-surface, and infrastructure. By default, based on the geo-services within the Tygron Geodesign Platform, the project area of the Huygenspark is subdivided into three terrain types: grassland, open land, and water. The attributes of importance to the Rainfall Overlay are the infiltration speed [m/day], the manning value [$s/\sqrt[3]{m}$] and the evaporation factor [-] for each surface type.

The infiltration speed is the speed at which water can infiltrate the surface and propagate downwards to the underground unsaturated zone. The infiltration speed of the grid cell is dependent on the infiltration speed of the terrain type and, if present, the infiltration speed of the construction, as the lowest infiltration value between the two is used. An infiltration value of zero means that no water can infiltrate the grid cell. For the Huygenspark, the infiltration values by default are 1 m/day, 1 m/day, and 0 m/day, for grassland, open land, and water, respectively. This also means that the water present in the canals cannot 'expand' during a rain event.

In addition, the manning value, which is short for the Gauckler-Manning coefficient, and the evaporation factor of the surface are of importance. The manning value defines the 'roughness' of the terrain against and according to flowing water. The manning value is by default retrieved from WikiEngineer (2021). The manning values are 0.03 $s/\sqrt[3]{m}$, 0.03 $s/\sqrt[3]{m}$, and 0.02 $s/\sqrt[3]{m}$, respectively for grassland, open land and water. Furthermore, the evaporation factor is by default 1.0, 1.0, and 1.3 respectively from grassland, open land and water. The weather's evaporation speed, previously mentioned as 1.5 mm/day, multiplied by the evaporation factor determines the rate of evaporation.

For the subsurface type and the corresponding infiltration speed and groundwater storage fraction, the Tygron Geodesign Platform normally takes the geodata from the *'Basis Registratie Ondergrond'*. Unfortunately, this data is absent for The Hague. Because of this, data from the historical geohydrological maps of The Hague, as shown in Figure 41, the Dinoloket, and the discussion with Arthur Hagen (A. Hagen, personal communication, January 28, 2021) were combined to determine the subsurface values and type of the Huygenspark. As can be seen in Figure 41, the Huygenspark historically consists of peat, with a sand layer less than 5 metres below the surface. However, if compared with current borehole data on Dinoloket, this differs. Currently, due to human interventions, the top layer is artificially placed sand, often having a thickness of approximately 1 metre. As the Groundwater Mode is deactivated, only the top layer (unsaturated zone) is of importance. Because of this, values related to sand, with a small fraction of peat, have been selected. The water storage percentage, the fraction of water stored per volume, is set to be 0.65, with a groundwater infiltration speed of 0.1223 for the unsaturated zone, while the saturated zone has a hydraulic conductivity of 0,02 m/day.

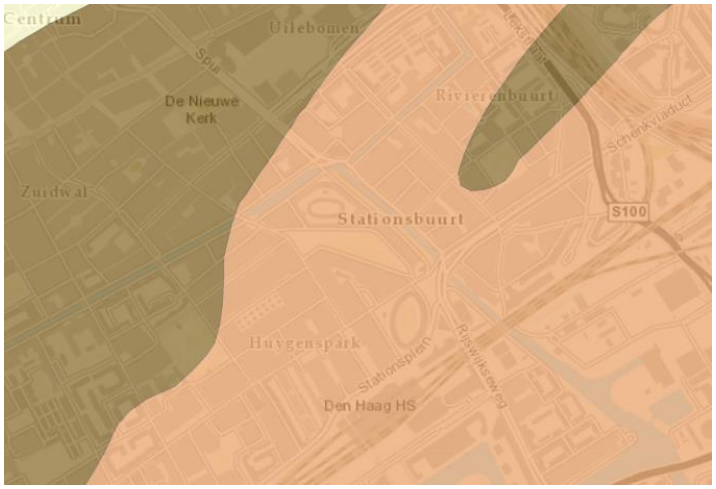

Figure 41: Geohydrological map of the Huygenspark (Gemeente Den Haag, 2021). Both colours show peat ('Hollandveen') on top of a sand layer ('Laagpakket van Wormer'). For the lighter colour, this sand layer is less than 5 metres below the surface.

A.3 Validation

After configuration of the model, four precipitation events were simulated (30, 50, 70, and 100 mm/hour). To validate whether the simulations corresponded with reality, the simulations were discussed with A. Hagen, policy advisor for the Team Sewage System, Roads and Subsurface at the Service Urban Management (A. Hagen, personal communication, February 18, 2021). Most of the simulation seemed to correspond to reality and/or the Klimaatatlas. However, two attention points were called into question whether simulated correctly.

The first area, indicated in red in Figure 23, has only a minor inundation in the Tygron simulation, whereas in the Klimaatatlas, as well as in reality, this area has serious water issues. A. Hagen recommended checking the correctness of the heightmap (A. Hagen, personal communication, February 18, 2021). However, after looking at the AHN geodata that serves as input for the Tygron model, an incorrect height did not become apparent. Because the maps are used for general communication purposes, it was decided to leave this detail and not change the heightmap manually to a lower number.

The second attention points were the tunnel at the Rijswijkseweg and the tram tunnel underneath the train tracks, as indicated in yellow in Figure 42. As no pumps were implemented in the model, as discussed before, the situation was simulated worse than A. Hagen remembers. Through the help of H. Latenstein, a technical employee at the Water, Constructions and Installations department, the following pump capacities were provided: 270 m^3/hour at the Rijswijkseweg and 180 m^3/hour at the tram tunnel (H. Latenstein, personal communication, February 25, 2021). As these pump capacities were small compared to the sewage system capacity (approximately 0.3%), the discount method, as discussed before in A.2.2, was unnecessary. However, after installing the pumps, the inundation at the tunnels remained.

Besides the validation with A. Hagen, the simulations were compared and discussed with the 3Di-model of A. de Jonge, a graduate student at Deltares working on the 3Di-model for extreme rainfall events for the entire city of The Hague (A. de Jonge, personal communication, February 22, 2021). One of her simulations is shown in Figure 43. Her simulations corresponded with the Tygron simulations, as her model gave the same dark issue-areas. She also implemented the same pumps, with the same capacity, and also continued to have inundation at the tunnels. Because of this, the pump capacity was not manually increased to have a more visually appealing picture.

Figure 42: Inundation map of the Tygron Model for 70 mm/hour directly after the hour of precipitation with two attention points: the pumps for the Rijswijksewe tunnel (yellow 1) and the tram tunnel (yellow 2) and the height of the red area.

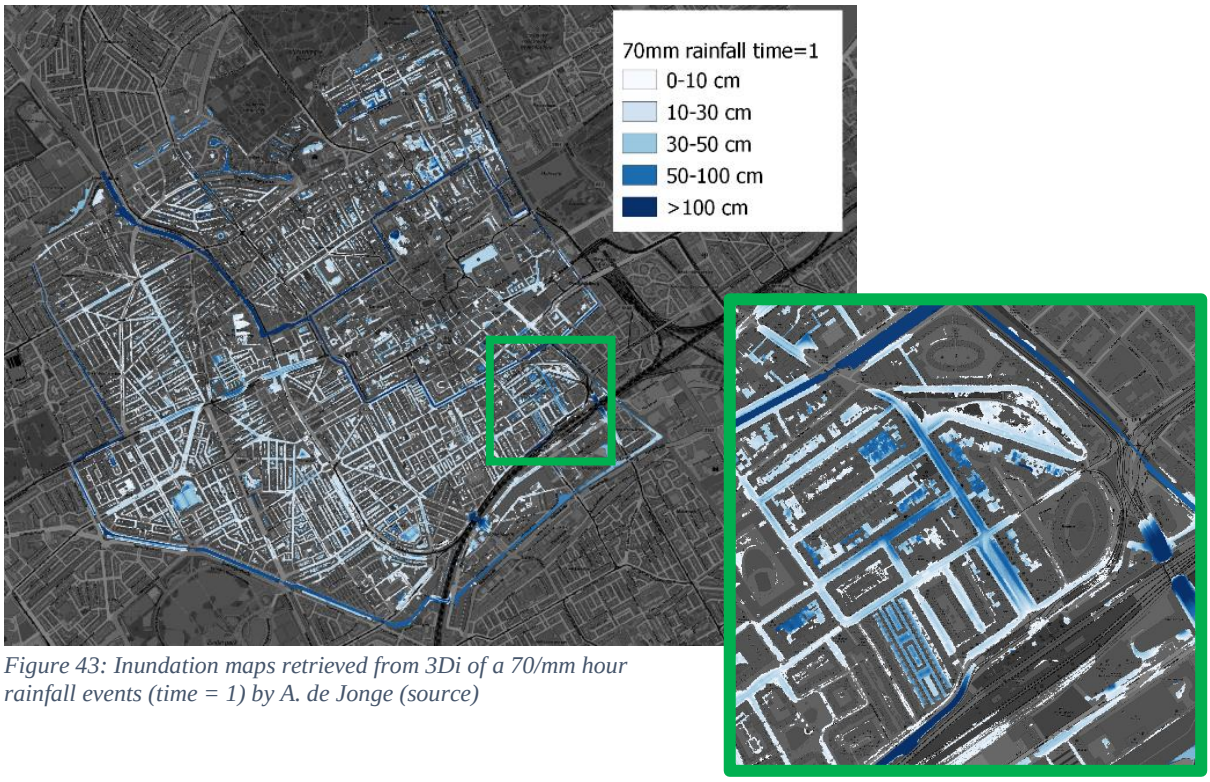

Figure 43: Inundation maps retrieved from 3Di of a 70/mm hour rainfall events (time = 1) by A. de Jonge (source)

Appendix B

Interviews for Context and Adaptation Tipping Points

Seven interviews have been carried out, with in total six employees. One employee was interviewed twice due to time constraints during the first interview. The seven interviews gave insight into the organisational discourse and context of the Municipality of The Hague from various departments. It also gave insight into the status quo in climate change adaptation and the possibility of applying adaptation tipping points. Furthermore, it contributed to defining the socio-political objectives for defining the adaptation tipping points of the Municipality of The Hague. The seven interviews that were carried out are shown in Table 1.

Table 6: Overview of the interviews held within the Municipality of The Hague. For an understanding of the listed Teams and Services within the Organisational Structure please refer to Figure 14 in Chapter 4

Nr.	Service	Team or Department	Job Title	Date
1	Urban Management	Sewage System, Roads and Subsurface Team	Project Leader	*19th of November 2020*
2	Urban Management	Policy Department	Policy Advisor, working on the Climate Adaptation-file	*27th of November 2020*
3	Public Affairs	Sustainability, District and Neighbourhoods	Advisor	*30th of November 2020*
4	Urban Development	Sustainable Living Environment Team	Policy Advisor	*3rd of December 2020*
5	Administrative Service	Resilience Team	Chief Resilience Officer	*7th of December 2020*
6	Urban Management	Department General Affairs and Management Support	Board Advisor	*18th of December 2020 & 4th of January 2021*

B.1 Original quotations in Dutch

The following quotations have been used in the Context Chapter. On the left side, it shows the translation to English, while on the right side it shows the original quote in Dutch.

Board Advisor of the Urban Management Board

"Our entire organisation is incredibly oriented around projects and budgets, and that is what we have approval for. This system is constructed quite like a military organisation, and that is also how we execute them. This is why our type of organisation also struggles with this subject"	*"Onze gehele organisatie is ontzettend ingericht op projecten, budget, daar hebben we een akkoord voor. Die zien best een beetje militair organisatorisch in elkaar. En dat voeren we uit. Dus ook de organisatie die we zijn, wringt ook met dit onderwerp"*
"It has to be clear from which department you are, but we have a municipal interest and often	*"Het moet wel duidelijk zijn waar je van bent, maar ja, we hebben een gemeenschappelijk*

people act from their service or department interest. That is a safe group and people find that easier. Because if it becomes a bit more difficult, well it becomes more difficult, and it gets in the way of things"	*belang en heel vaak wordt er vanuit dienst belang, afdelingsbelang, weet ik veel wat gehandeld en dat is dan een soort veilige groep en dat vinden mensen dan makkelijker en als het wat moeilijker wordt, ja, dan is het moeilijker. Ja, dat staat dingen wel in de weg"*

Chief Resilience Officer

"These are often long-term challenges that you want to tackle now, but investing more money into it is complicated, because it is a long-term challenge which might not happen." [...] "In a municipal organisation, many people and politicians are more focused on the short-term, as they are often judged based on the short-term achievements"	*"Het zijn vaak lange termijn uitdagingen die je nu al wil voorkomen, maar als je daar meer geld op moet investeren, ja, dan is dat weer heel ingewikkeld, want dat is pas langere termijn en misschien gebeurt het wel niet […] Dat komt ook van dat het lange termijn is en dat is het een gemeente eigen dat mensen toch gewoon meer gericht zijn op de wat kortere termijn zeg maar en dat heeft ermee te maken dat je in een politieke organisatie zit, waar natuurlijk mensen vooral ook wel worden afgerekend op wat kortere termijnen"*
"For a lot of projects, people really think within their own silo: "This is what I have to achieve", "These are my responsibilities", which is why they are less aware of the challenges that also at play and can influence their own project"	*"Maar bij heel veel andere projecten, zijn mensen heel erg in hun eigen silo aan het denken over "dit is wat ik moet bereiken", "dit zijn mijn verantwoordelijkheden", waardoor ze ook minder bewust zijn van uitdagingen die ook spelen die ook hun project kunnen beïnvloeden."*

Project Leader of the Sewage System, Roads and Subsurface Team

"There are not many people that have the knowledge and the ability to see the complexities associated with heat stress, drought, and water. […] We are very object-oriented. The sewage team has knowledge about sewage. Interaction between them is difficult and making decisions between them is difficult. This is also because they all have different income sources"	*"Er zijn weinig mensen die van hitte, droogte en water, allemaal daar verstand van hebben en de complexiteit zien. Maar wel meer soms dan mensen op het uitvoeringsniveau. We zijn erg object georiënteerd: riolering heeft kennis over de riolering. Interactie daartussen is lastig en het maken van afspraken daartussen is lastig. Ook omdat ze allemaal andere geldbronnen hebben."*

Advisor of the Sustainability, District and Neighbourhoods Department within Public Affairs

"It is organised in such a way that we really need to look at adaptation mainstreaming opportunities. There is not a department for it. There is also not an executive institution that has a budget to undertake something like this. So, when a street is being renovated, you have to look	*"Ja, het is zo vormgegeven dat we echt naar koppelkansen moeten kijken om het mogelijk te kunnen maken. Er is niet echt een dienst voor. Er is niet echt een uitvoerende instantie die ook budget heeft om zoiets te gaan ondernemen. Dus je moet gewoon kijken, wie gaan er bezig in de*

at who is renovating that street and how we would be able to implement climate adaptation"	*straat als die wordt heringericht en hoe kunnen we dan die klimaatadaptatie daar invulling geven."*

B.2 Base Interview Protocol in Dutch

Each interview protocol was adjusted to the person's individual department and expertise. However, they all started from the protocol, which served as the foundation, and is provided in this section.

Goedemorgen. Allereerst wil ik u heel erg bedanken voor uw tijd. Ik ben op dit moment bezig met mijn afstudeerproject voor de masters in watermanagement en wetenschapscommunicatie. Met dit interview hoop ik allereerst een beter beeld te krijgen van hoe beslissingen tot stand komen binnen de Gemeente Den Haag rondom klimaatadaptatie en ten tweede wat uw perceptie op de huidige en toekomstscenario voor de Stationsbuurt is, wat daarbij de doelstellingen zijn vanuit de gemeente en hoe adaptation tipping points, een methode die ik later zal uitleggen, kan helpen bij dit proces.

De data die ik verzamel met dit interview, zal alleen gebruikt worden voor mijn master scriptie, uitgevoerd voor de opleidingen International Land & Water Management aan de WUR en Communication Design for Innovation aan de TU Delft.

1. Vindt u het goed als ik deze meeting opneem via Teams? Dan kan ik het op een later moment terugluisteren.
    a. Nee: Vindt u het dan goed als ik de audio opneem via mijn telefoon?

2. Vindt u het daarnaast goed als ik uw naam en functie benoem in mijn uiteindelijke verslag?
    a. Zo ja, hoe wilt u gerefereerd worden?
    b. Zo ja, zou ik daarnaast mogelijke quotes uit dit gesprek (vertaald naar het Engels) in mijn uiteindelijke rapport op mogen nemen? En ziet u graag de gebruikte quotes in voordat ik het rapport publiceer op de repository van de TU Delft en/of inlever bij mijn begeleiders?

Introductie

3. Kunt u mij in het kort vertellen wat uw functie binnen de Gemeente Den Haag precies inhoudt?

4. Kunt u mij uitleggen op welke manier Dienst ___ betrokken is met de andere Diensten?
    a. En hoe zijn ze betrokken met klimaatadaptatie?

5. Bent u zelf betrokken bij klimaatadaptatie binnen de Gemeente Den Haag?
    a. Zo ja, op welke manier?

Besluitvormingsproces

Zoals aangegeven in de mail heb ik de afgelopen weken gesproken met personen van de Gemeente Den Haag. Ik heb daarbij een globaal beeld van het besluitvormingsproces rondom klimaatadaptatie binnen de gemeente getekend. Ik zou graag met u hier doorheen lopen. Ik wil hierbij benadrukken dat het een schets is en daarmee nog niet af is. En dat ik daarom graag heb dat u er kritisch naar kijkt en dat uw mening over het besluitvormingsproces kan en mag verschillen.

- *Check:* Had u tijd om de afbeelding thuis te bekijken?

6. *Zo ja*, toen u naar het proces keek, viel u dan iets op?

7. *Doorlopen afbeelding*: Input, Stappen, Output: Vindt u dat al deze processen kloppen en/of dat er bepaalde processen missen?

8. De aanpak voor klimaatproblemen en/of ontwikkelingen raakt vaak meerdere domeinen, hoe wordt dit aangepakt?

9. Had u zelf nog op- of aanmerkingen over de afbeelding?

Huidige situatie en toekomst situatie Stationsbuurt

Ik wil nu graag meer focussen op de huidige situatie en de toekomst situatie van de Stationsbuurt.

10. Bent u bekend met de doelstellingen en/of problemen voor de toekomst van de Stationsbuurt?

Zo ja, vervolg vragen. Zo nee, vragen worden globaal gesteld (in Den Haag in plaats van Stationsbuurt)

11. Hoe ervaart u de huidige klimaat en water situatie in de Stationsbuurt?
    a. *Controle:* Vindt u dat in de huidige situatie water, milieu of klimaatproblemen aanwezig zijn die moeten aangepakt worden?

12. Wat is het standpunt van de Gemeente op de huidige klimaatsituatie in de Stationsbuurt?

13. Verwacht u problemen in de toekomst voor de Stationsbuurt?
    a. Zo ja, wat ziet u als de grootste problemen voor de toekomst van de Stationsbuurt?

14. Op welke tijdschaal ziet u deze problemen ontstaan?

15. Welke klimaat effecten versterken dit probleem?

Normen en Doelstellingen Stationsbuurt

16. Wat is de rol vanuit de gemeente voor deze problemen?

17. Zijn er specifieke doelstellingen/normen voor de Stationsbuurt rondom deze problemen vanuit de Gemeente?

18. Hoe worden deze normen binnen de Gemeente Den Haag bepaald?
    a. Wie bepaalt deze normen?
    b. Hoe heeft dit tot betrekking tot het besluitvormingsproces?

19. Hoe wordt er bepaald of een wijk aan de nomen voldoet?

20. Er zijn ook vele normen, zoals hittestress, die lastig zijn om te normeren, hoe pakt de gemeente dit aan?

Adaptation Tipping Points Methode

Adaptation tipping points, ook wel omslagpunten, geven weer wanneer bepaalde normen of doelstellingen niet meer worden behaald voor verschillende toekomstscenario's. Dit kan bijvoorbeeld op korte termijn zijn, bijvoorbeeld over een jaar, maar ook over een tijdsbestek van 30 jaar. Deze punten geven dus weer wanneer een keuze moet worden gemaakt naar een andere aanpak of methode om binnen de norm te blijven. Hierdoor ontstaat een beslisboom, genaamd adaptatiepaden, waarin zichtbaar wordt wanneer keuzes moeten worden gemaakt en wat deze keuzes dan zijn om binnen de normen te blijven.

21. Controle: Is het nu helder wat adaptation tipping points, ook wel omslagpunten, zijn?

22. Zou u de hiervoor genoemde normen […] benoemen als omslagpunten?

23. Denkt u dat zo'n methode toepasbaar of nuttig zou kunnen zijn voor de Gemeente?
    a. Zo nee
        i. Waarom niet?
        ii. Ziet u meer mogelijkheden in het vertalen naar meekoppelkansen?
    b. Zo ja
        i. Waar binnen het besluitvormingsproces ziet u de mogelijkheid om deze aanpak toe te passen?
        ii. Op welke manier ziet u deze methode toegepast worden?
        iii. En door wie?

Afsluiting

Ontzettend bedankt voor uw tijd en dat u uw inzichten met mij wilde delen. Ik zal deze meenemen in mijn overzicht van de besluitvorming binnen de gemeente Den Haag rondom klimaatadaptatie.

- Heeft u daarnaast nog iets wat u graag wilt toevoegen?

- Heeft u nog suggesties voor andere mensen die ik kan interviewen om een beter beeld te krijgen van de problematiek rondom de Stationsbuurt?

- Als ik straks meerdere mensen heb gesproken en visueel het besluitvormingsproces heb opgesteld, kan ik deze dan per mail opsturen als laatste controle of u zich erin kan vinden?

Appendix C

Interviews for Circulation Phase

Fourteen interviews have been conducted with employees within the Municipality of The Hague. None of the interviews had a colour vision deficiency. In the third column, the team is listed unless unknown, then the department is stated.

Table 7: Overview of the interviews held within the Municipality of The Hague. For an understanding of the listed Teams and Services within the Organisational Structure please refer to Figure 14 in Chapter 4

Nr.	Service	Team or Department	Job Title	Thematic Expertise	Date
1	Urban Development	Team Sustainable Living Environment	Senior Planner	General Thematic Expert	29th of March 2021
2	Urban Management	Team Sewage, Roads and Subsurface	Programme Manager	Specific Thematic Expert	29th of March 2021
3	Urban Development	Team Centrum/Haagse Hout/Laak	Urban Planner	Nonthematic Expert	31st of March 2021
4	Urban Management	Department Advice Outdoor and Greenery	Policy Officer	Nonthematic Expert	31st of March 2021
5	Urban Development	Team Sustainable Living Environment	Policy Officer	General Thematic Expert	1st of April 2021
6	Urban Development	Team Sustainable Living Environment	Policy Advisor	General Thematic Expert	1st of April 2021
7	Urban Management	Policy Department	Policy Advisor	General Thematic Expert	7th of April 2021
8	Urban Management	Department Water, Constructions and Installations.	Senior Technological Employee	Nonthematic Expert	8th of April 2021
9	Urban Management	Engineering Firm The Hague	Public Space Designer	Nonthematic Expert	8th of April 2021
10	Urban Management	Engineering Firm The Hague	Landscape Architect	Nonthematic Expert	9th of April 2021
11	Urban Development	Team Laak/Transvaal/Schilderswijk	Urban Planner	Nonthematic Expert	9th of April 2021
12	Urban Management	Engineering Firm The Hague	Public Space Policy Advisor	Nonthematic Expert	13th of April 2021
13	Urban Management	Team Sewage, Water, and Subsurface	Technological Employee	Specific Thematic Expert	14th of April 2021
14	Urban Development	Department Mobility	Policy Advisor	Nonthematic Expert	14th of April 2021

C.1 Original Quotations in Dutch

Interviewee 1

No direct quotations have been used.

Interviewee 2

"For most people, this is not much of use. It says a lot to me, but I am a specialist in the matter. I know what it means"	*"Ik denk dat de meeste mensen niet heel veel aan hebben. Mij zegt het heel veel, maar ik zit helemaal in de materie. Ik weet wat het is"*

Interviewee 3

"It [Map 1] is a kind of reality to which we relate, but which is still quite abstract, because you read water nuisance, but you do not really get a feeling for it"	*"Het is een soort werkelijkheid waar we ons toe moeten verhouden maar die nog heel abstract is, want ja je leest wateroverlast, maar je krijgt er nog niet zo'n goed gevoel bij"*
"Number 2 is a really good translation of Map 1, which makes it really concrete for one specific component; what will happen and what does this mean for the accessibility. It thus clearly shows the urgency"	*"Nummer 2 is een hele goede doorvertaling daarvan die het heel concreet maakt voor 1 specifiek onderdeel, van wat gaat er nu gebeuren of wat betekent dat voor bereikbaarheid. Dus dat geeft heel erg de urgentie aan."*
"I notice that within our organisation this is not really managed well. You miss the link between the different departments"	*"Maar dat is nu, dat merk ik, beetje in de organisatie waar we nu in zitten is het niet heel goed geregeld. Daar mis je toch die schakeling tussen de verschillende afdelingen"*
"You do not only have the sustainability interest. You couple the interest directly to a piece of Mobility, which we are also there for. You might also couple it to the economy or the accessibility of shops. This way you make sustainability interwoven with the project assignment. It is not just a loose element anymore, which I unfortunately sometimes see happening and it becomes one of many chapters, but it now can become an integral part of the policy or of other departments"	*"Je hebt niet alleen het belang duurzaamheid. Je koppelt het belang direct aan een stukje mobiliteit, waar we ook voor zijn. Je koppelt het aan economie aan de bereikbaarheid van winkels. Dat maakt het duurzaamheid veel meer verweven wordt in de project opdracht. Dat het niet meer een losstaand element is zoals ik het nu zie helaas nog wel zie gebeuren dat het een van de vele hoofdstukken is, maar het kan echt een integraal onderdeel worden van het beleid van andere afdelingen."*

Interviewee 4

"That is now and again an issue at Municipality land, as everyone on their, sounds disrespectful, little island tries their best to realise all the goals of the Municipality of The Hague which we drafted together. And at that speed, you could just forget your colleagues sometimes"

"Dat is nog wel eens een klein beetje een probleem in Gemeente land dat iedereen op zijn, klinkt oneerbiedig, op z'n eilandje echt z'n best doet om alle doelen die we voor de gemeente den haag met elkaar hebben gesteld om die te realiseren. En in de snelheid zou je daar in zo maar eens je collega's kunnen vergeten."

"What you actually see is that, of course, I was thinking rather one dimensional, I was really looking at the greenery and the planting of trees, but of course this is a much more important issue than just the trees"

"Ja wat je eigenlijk ziet is, en natuurlijk was ik heel een dimensionaal net bezig echt, ik keek echt naar groen en naar bomen beplanting, maar uiteraard is dit een veel belangrijker issue dan alleen maar kijken naar de bomen"

Interviewee 5

"I think this is just a bit too much. It directly makes a lot of choices, while there are actually many more choices to be made. You can also look at what is being renovated or demolished and that would show that there is way more possible"

"Ja het is misschien iets te, worden al direct heel veel keuzes gemaakt zeg maar. Terwijl d'r eigenlijk wel meer keuzes zijn. Dat is wat ik en bijvoorbeeld zou je moeten kijken van waar word bijvoorbeeld gerenoveerd of gesloopt zo en dan dat biedt dan veel meer kan."

Interviewee 6

"I can imagine that certain areas have large water nuisance, but that does not automatically mean there is also an inaccessibility of roads. I think that if you only show Map 2 you miss a lot"

"Ja, want ik kan me voorstellen dat er in een bepaald gebied sprake kan zijn van grote wateroverlast, maar dat dat niet automatisch betekent dat er ook sprake is van onbegaanbaarheid van wegen. Dus als je alleen kaart 2 zou laten zien denk ik dat je heel veel mist"

"I think that, in many ways, there are a lot of seizable chances, but you have to point them out together. You have to enter a conversation about them and then together also weigh the options"

"Ik denk dat er op heel veel vlakken kansen te pakken zijn, maar dan moet je ze wel benoemen met elkaar, maar dan moet je er wel over in gesprek met elkaar en dat ook samen afwegen."

Interviewee 7

"I think this map is quite limited. Especially the chance to strengthen the green-blue structure [Map 3]. You can take that much broader. You have greenery structures, tree rows, tree driplines that you can also use for infiltration, and existing roofs, which you can work on together with the city instead of just the municipality. So, to not just focus on demolition

"Ik vind het nogal weinig. Zeker die eerste kans om groen-blauwe structuur te versterken. Die kan ej ook breder pakken volgens mij. Je hebt ook groenstructuren, bomen rijen, boomspiegels kan je ook gebruiken voor je infiltratie, uh de daken dus je zou ook meer met de stad samen kunnen werken niet alleen als gemeente aan de slag maar ook bestaande daken dingen gaan doen, niet

projects and new constructions, which I presume it is focused on. Then the map becomes way more interesting if I may say so, because it will show more chances. Now it feels like the entire neighbourhood has an issue, and you are going to fix it in those four areas. That is too limited. There is way more possible"	*alleen op de sloop nieuwbouw waarvan ik dus vermoed dat het is. Dan wordt die kaart interessanter wat mij betreft, omdat je dan nog meer kansen weergeeft. Dit komt mij een beetje over van die hele wijk heeft een probleem en dat gaan we even oplossen in deze vier stukjes. Dat. Dat is te beperkt denk ik. Ik denk dat dat wat meer kan dus".*

Interviewee 8

No direct quotations have been used.

Interviewee 9

"I do think that this might require a different working method. It requires quite some assertiveness"	*"Maar ik denk dat je op hele andere, op en dat vergt misschien wel een andere werkwijze. Dat vergt behoorlijk wat assertiviteit."*

Interviewee 10

"I am inclined to think: Are these the only areas where there are chances? How does that work? And why?"	*"Nou ja dat ben je geneigd te denken van zijn dit dan de enige gebieden waar kansen zijn en hoe zit dat dan? En waarom?"*
"That is difficult to say, because that depends on what you want to tell your own colleagues"	*"Ja, dat kan ik moeilijk zeggen, want dat ligt er aan wat je dan wilt vertellen. Wat je aan je eigen collega's wilt vertellen."*
"What are we doing thens? How are we going to tackle this?"	*"Ja, wat doen we dan jongens? Hoe kunnen we dat tackelen?"*

Interviewee 11

"This is the same for if you want to realise something. For example, sometimes you have to cross water, so you aim to build five bridges. In the end, you might only get three, because you run out of money or the other two were not deemed necessary. But if I only draw one bridge you can only get one or perhaps even none. So I always say, put your ambitions high"	*"Het is hetzelfde als je iets wilt realiseren, soms wil je het water oversteken op verschillende plekken heb je wil je wel vijf bruggen hebben en dan is het uiteindelijk dan krijg je er bijvoorbeeld misschien maar drie. Omdat dan al het geld op is of omdat die twee toch niet zo noodzakelijk geacht zijn. Maar als ik maar 1 brug teken krijg ik er maar 1 of helemaal niks. Dus ik zeg altijd, zet je ambitie hoog"*
"This [Map 1] is just signalising the issue and I always notice that if people signalise nothing happens. People think 'oh well, that knowledge is nice, but we shall see'."	*"Het ene is gewoon signaleren en ik merk altijd dat als mensen het signaleren dan gebeurd er niks. He, dan denken ze van oh nou leuk die kennis, zien we dan wel weer."*

"You place it on the political agenda. This [Map 2] is a tool to maybe have it faster or more specific on the political agenda, which maybe causes resources to made available earlier or that they are forced to think about the city differently"	*"Dus dit is wel een middel om het misschien sneller of scherper op de politieke agenda te krijgen en dat er misschien eerder middelen voor vrij worden gemaakt of dat men gedwongen wordt om anders over die stad na te denken."*
"I think that it does not just become a climate story. It becomes a story of safety. It becomes a story of liveability. So, the more different disciplines you appeal to, the more support it gains from different departments within the municipality or the higher it comes on the political agenda, and the more councillors have to deal with it. [..] It becomes a broader story. You actually say, no this is not just a problem of the street, this is a problem for all of us."	*"Nou ik vind dat het niet alleen maar een klimaat verhaal wordt, maar dat het ook een veiligheidsverhaal wordt, of dat het een leefbaarheidsverhaal wordt, dus hoe meer verschillende disciplines je kan aanspreken hoe meer draagvlak d'r vanuit verschillende afdelingen binnen de gemeente, of hoe je hoog je het op de agenda gaat agenderen, hoe meer wethouders ermee te maken krijgen […] Waardoor het gewoon een breder verhaalt wordt. Eigenlijk zeg je gewoon ja, nee dit is niet alleen een probleem van de straat, dit is een probleem voor ons allen."*
"It is about how you build your story. If you only mention the issues, it will be a grumpy story. If you have chances, you offer people an alternative. If you only talk about chances, people might forget what the issue was about"	*"Dus het is ook hoe je je verhaal opbouwt. Als je alleen maar de problemen benoemt, wordt het een heel sikkeneurig verhaal. Als je kansen hebt, biedt je mensen een alternatief. Als je alleen maar over die kansen praat, dan gaan mensen vergeten wat het probleem was."*

Interviewee 12

"You now have the chance to couple chances to the sewage repairs. That is a chance you have to take now. It cannot wait 5 years, because then the first part of the sewage is already repaired and the chance is over. Yes, these kinds of maps help enormously. Of course, for the other maps [Map 1 or 2] you can see a kind of urgency, because yes that rain shower can fall, but it can fall in 25 years, in 5 years or 100 years, no idea, and that does give urgency, but not for tomorrow or the day after tomorrow. This gives clarity. This is something concrete that we can do something with. […] Here, you couple a concrete chance to something that within the municipal system has urgency."	*"Nou ja, het zet toe dat je een kans nu hebt om op een om met die vervanging van die riolering om daar mee te liften en dat is een kans die je nu moet grijpen en dat je die niet nog 5 jaar kan laten gaan, want dan is het eerste stuk riool is al vervangen en ben je je kans voorbij. En dat ja, dit soort kaarten helpen daar enorm bij, en dat is natuurlijk bij de andere dat je een soort urgentie wel ziet, ja die bui kan wel vallen, maar hij kan over 25 jaar ook vallen, of over 5 jaar of over 100 jaar, geen idee, en dat geeft wel urgentie, maar niet voor morgen en ook niet voor overmorgen. Dit geeft helderheid. Dit geeft concreetheid waar we iets mee kunnen. […] Nou ja, je koppelt een concrete kans aan waar je in het gemeente systeem ook urgentie op is."*

Interviewee 13

No direct quotations have been used.

Interviewee 14

"I have an image of the emergency services. I know what they are going to do over there and why. […] It makes it visual in my head what the issue exactly entails"	*"Nou ja, als er inderdaad staat, specifiek he die veiligheidsdiensten, dan he daar heb i keen beeld bij. Ik weet wat die veiligheidsdiensten aar komen doen en waarom […] dat maakt het heel, dat maakt in mijn hoofd visueel wat het probleem dan precies inhoudt"*
"They bring one image together: there is water nuisance and this is where you can do something about it, and guys, the issue is really big because if we let it get this far the emergency services also cannot reach it any more, so to speak. They all bring a joint story together"	*"Ze brengen samen natuurlijk 1 beeld van er is wateroverlast en hier zou je er wat aan kunnen doen en jongens het probleem is heel groot want als we er zo ver laten komen kunnen de hulpdiensten er ook niet meer bij, bij wijs van spreken. Ze brengen allemaal een gezamenlijk verhaal."*

C.2 Base Interview Protocol in Dutch

Each interview protocol was adjusted to the person's individual department, knowledge and expertise. However, they all started from the protocol, which served as the foundation.

Goedemorgen. Allereerst wil ik u heel erg bedanken voor uw tijd. Ik had u over de mail al kort toegelicht waar mijn afstudeerproject over gaat, maar ik licht het graag nog even een keer verder toe. De afgelopen jaren is het onderwerp van klimaatverandering en adaptatie steeds groter geworden, ook binnen de publieke sfeer zoals de Gemeente. Mede door deze groei produceren en communiceren wetenschappers veel verschillende klimaatkaarten, zoals de Den Haag Klimaatatlas. Echter, in hoeverre deze modellen aansluiten bij de perceptie van hun gebruikers en in hoeverre ze gebruikt kunnen worden als ondersteuning bij besluiten die gemaakt moeten worden door gebruikers is nog vrij onbekend. Ik wil daarom met dit interview duidelijkheid scheppen in de factoren die meespelen bij het kijken naar klimaatkaarten en hun toepasbaarheid, zowel op individueel vlak, als met collega's van de Gemeente.

Om dit te onderzoeken focus ik mij in het gesprek op het projecteren van extreme regenval; een van de mogelijke klimaatveranderingen met effecten op het stedelijk gebied van Den Haag. De extreme regenval wordt besproken en geprojecteerd voor het Huygenspark, een typische versteende stadswijk binnen de Stationsbuurt. Deze buurt is gekenmerkt door het Hollands Spoor, de Stationsweg en het Huijgenspark. Ik zal het gesprek beginnen met introductie vragen, waarna ik vier kaarten een voor een zal laten zien. Hierna zal ik de kaarten naast elkaar leggen, waarbij we ze zullen vergelijken voor individuele beslissingen en groepsbeslissingen.

Tijdens het gesprek ben ik dus op zoek naar uw persoonlijke perceptie op de kaarten en op welke manier u ze zou gebruiken van het Huygenspark. Ik wil benaderen dat er dus geen goed of fout antwoord is en dat ik vooral benieuwd ben naar uw kijk en aanpak. Probeer tijdens het interview de kaarten zo veel

mogelijk met betrekking tot uw dagelijks werk en mogelijkheden binnen de gemeente te zien en hoe u er in een echte werksituatie op zou reageren.

De data die ik verzamel met dit interview, zal alleen gebruikt worden voor mijn master scriptie, uitgevoerd voor de opleidingen International Land and Water Management aan de WUR en Communication Design for Innovation, aan de TU Delft. Daarnaast wordt uw naam niet genoemd in het uiteindelijke verslag. Er zullen wel enkele initiële vragen zijn over uw betrokkenheid, kennis of houding rondom extreme regenval en adaptie en uw rol binnen het team, maar dit zal zo min mogelijk aan individuele personen gekoppeld worden.

- Vindt u het goed als uw rol binnen het team en andere persoon-gerelateerde informatie, met zo min mogelijk verwijzing naar het individu, worden genoemd in het uiteindelijke verslag?
- Vindt u het daarnaast goed als ik het gesprek via Teams opneem?
    - Nee: Vindt u het goed als ik de audio opneem via mijn telefoon?
- Om het interview te analyseren en coderen zal ik het interview transcriberen. Zou u het een probleem vinden als ik quotes en eventueel de transcriptie plaats in mijn uiteindelijke verslag?
    - Zo ja, vindt u het fijn om de quotes en/of transcriptie in te zien voordat ik het rapport publiceer?
- We maken daarnaast gebruik in dit onderzoek van plaatjes en kleuren. Kunt u kleuren goed onderscheiden?

Ik stuur natuurlijk mijn rapport naar u op, en u bent van harte welkom om mijn afstudeerpresentatie bij te wonen. Deze vindt ergens eind juni plaats, als het allemaal goed gaat.

Deel 1: Persoonlijke Factoren

1. Kunt u mij in het kort vertellen over uw eigen rol en werkzaamheden bij de Gemeente Den Haag?
    a. Situaties waarmee u rekening moet houden met potentiele extreme regenval?
    b. Hoe veel bent u bekend met de huidige situatie en toekomstige gevolgen van extreme regenval in stedelijke gebieden in Nederland?
    c. Heeft u wel eens klimaatmodellen en kaarten, bijvoorbeeld de Den Haag Klimaatatlas, afgelezen?
        i. Zo ja, wanneer of waarvoor heeft u dit gebruikt?

2. Hoe groot schat u het probleem van extreme regenbuien in de gemeente Den Haag?
    a. Heeft u recentelijk hevige wateroverlast ondervonden?
    b. En welke rol denkt u dat de gemeente hierin moet spelen?

3. Schat u in dat uw standpunt over extreme regenbuien en de rol van de Gemeente gedeeld wordt binnen uw team van de Gemeente Den Haag?

4. Hoe bent u bekend met het Huygenspark, gelegen in de Stationsbuurt?

Deel 2. Initiële Reactie en Cognitie

Ik wil nu graag met u door vier verschillende manieren van het weergeven van extreme regenval lopen. Eerst zal ik u een introductie geven over het Huyenspark, waarna ik de kaarten, inclusief korte omschrijving, een voor een aan u zal laten zien. Ik wil hierbij benadrukken dat ik benieuwd ben naar wat er door uw hoofd gaat terwijl u kijkt naar de kaarten. Er is daarom niet een goed of fout antwoord.

- U kunt nu eerst rustig de introductie lezen. Als u klaar bent, laat mij het dan weten, dan zullen we doorgaan naar het eerste kaartje. Indien u het nodig vind, kunnen we altijd terug gaan naar de introductie.

5. We gaan nu door naar de eerste kaart. Het bevat zowel een korte tekst als een afbeelding. Ik wil u nu vragen als we naar de volgende pagina gaan om hardop na te denken over waar u naar kijkt, wat u zoekt of wat u opvalt, waar u aan denkt.

Ondersteuningsvragen, indien hardop denken lastig gaat:

- Kunt u mij uitleggen waarom deze dingen u opvallen? Waarom benoemt u dit?
- Wat vindt u van deze kaart ten opzichte van de vorige?

‘Probleem’-kaartjes

1. Hoe groot schat u de ernst van het probleem?
    - Indien laag: Wanneer zou het probleem volgens u ernstig zijn?
    - Indien hoog: Wat zijn de aspecten die voor u het probleem ernstig maken?

2. Hoe groot schat u het risico dat dit plaatsvindt in het Huygenspark:
    - Op dit moment?
    - Over 30 jaar?

3. Hoe groot schat u de noodzaak tot handelen?
    - Aan wat voor tijdspan moet er dan gedacht worden?

‘Oplossing’-kaartjes

4. Hoe groot schat u de noodzaak om deze kansen te pakken?
    - Aan wat voor tijdspan moet er dan aandacht worden?

Deel 3: Invloed op Individuele Beslissingen en Factoren

We hebben nu alle vier de kaarten individueel van elkaar gezien en u bent nu wat meer bekend met de problemen en kansen die er mogelijk zijn en liggen omtrent extreme regenval in het Huygenspark. Daarnaast hebben we daarvoor uw dagelijkse werkzaamheden besproken en op welke manier u te maken kan krijgen met extreme regenval.

6. Binnen uw eigen werkzaamheden, in wat voor situaties kan u zelf rekening moeten houden met potentiële extreme regenval?
        i. Indien geen situaties, wel voor (toekomstige) problemen van het klimaat?
    b. Tjdens deze situaties, waarover moet u zelf besluiten nemen?
        i. Denk aan plannen, ontwerpen openbare ruimte, budgettering

Ik wil nu een voor een deze keuzes doorlopen.

7. Kunt u mij uitleggen hoe u dit besluit neemt?

a. Welke factoren zijn voor u belangrijk om dit besluit te maken?

8. Welke kaart zou u gebruiken bij het maken van dit besluit?

9. Kunt u mij uitleggen waarom u deze kaart zou gebruiken?
    a. Op welke manier beïnvloedt deze kaart de factoren die u zonet genoemd heeft?
    b. En waarom zou u de andere kaarten niet gebruiken?

Deel 4: Inschatting Invloed Beslissingen Collega's

We hebben het nu gehad over hoe de kaarten u kunnen helpen bij het nemen van besluiten en op welke manier ze dat zouden doen. Ik wil het nu graag hebben over hoe de kaarten iets zouden betekenen in keuzemomenten samen met uw collega's.

10. In wat voor situaties wordt er in groepsverband rekening gehouden met potentiële extreme regenval?
    a. Advies geven, Maatregelen/Ontwerpen (Overtuigen, Promoten), Informeren
    b. Hoe wordt deze keuze gemaakt in groepsverband?
    c. Wat voor belangrijkste collega's zijn er, naast uzelf als …, betrokken bij deze keuze?
        i. Stedenbouwkundige, beleidsmaker, beheerder, projectmedeweker/manager

11. Hoe schat u in dat een collega zo'n besluit zou nemen?
    a. Welke factoren denkt u dat belangrijk zijn om voor uw collega zo'n besluit te maken?

12. Welke kaart zou u gebruiken tijdens dit gesprek met uw collega's?
    a. En met welk doel zou u deze kaart gebruiken?
        i. Overtuigen, promoten, informeren, adviseren

13. Kunt u mij uitleggen waarom u deze kaart zou gebruiken?
    a. Op welke manier beïnvloedt deze kaart de factoren die u zonet genoemd heeft?
    b. En waarom zou u de andere kaarten niet gebruiken?

Deel 5: Afsluiting

Ontzettend bedankt voor uw tijd en dat u uw inzichten met mij wilde delen. Ik zal deze meenemen in mijn onderzoek.

14. Heeft u daarnaast nog iets wat u graag wilt toevoegen?

15. Kent u nog andere collega's waarvan het interessant zou zijn of met hem of haar in gesprek te gaan?

16. Wilt u daarnaast betrokken blijven bij de resultaten/het verslag?

Appendix D

Thematic Analysis Themes and Codes

During the thematic analysis, three themes became apparent:

1. Individual Interpretation;
2. Collective Interaction;
3. Graphical Representation;

Each of these three themes, with their subsequent codes and descriptions, are shown in the Tables below. Each of these codes was coupled to Map-codes to make 'smart-codes' in Atlas.Ti. The following Map-codes were used: 'Map 1', 'Map 2', 'Map 3', 'Map 4', 'Combination of Maps', and 'Comparison of Maps'.

Table 8: First Theme of Individual Interpretation and the six subsequent codes and their description in Dutch

THEMA 1: INDIVIDUELE INTERPRETATIE		
Nr	**Code**	**Omschrijving**
1	Visualisatie	Probleem voorstellen/zien/visualiseren en effect daarvan.
2	Probleem	Hebben het over het probleem (urgentie, concreetheid).
3	Breder kansverhaal	Schets een groot ambitieus kansverhaal.
4	Kansen	Hebben het over de kansen.
5	Onderbouwing	Wanneer gesproken over waarom is dit een kans.
6	Probability	Hebben het over de kans dat het voorkomt.

Table 9: Second theme of collective interaction and the eight subsequent codes and their description in Dutch

THEMA 2: Collectieve Interactie		
Nr	**Code**	**Omschrijving**
1	Actie	Gesproken over handelen, zoals maatregelen en vervolgstappn.
2	Inschatting Interpretatie	Hoe andere collega's de kaart zouden lezen.
3	Interactie	Omtrent interactie naar collega's toe: wat voor communicatie middel kan het zijn en hoe kan dit gebruikt worden.
4	Collectief Probleem	Praten in 'ons' en 'wij samen'-vorm.
5	Keuze	Afwegingen en beslissingen maken.
6	Omdenken	Aangeven dat het een verandering is in de huidige manier van de denken.
7	Werkwijze	De manier waarop het de werkwijze beïnvloedt.

Table 10: Third Theme of graphical content and representation and the eight subsequent codes and their description in Dutch.

THEMA 3: GRAFISCHE INHOUD		
Nr	**Code**	**Omschrijving**
1	Manier van Lezen	Aanpak lezen tekst en plaatje.
2	Data	Data in twijfel stellen in vergelijking tot praktijk/expertise.
3	Tekst	Gefocust op tekst.
4	Grafisch	Gefocust op grafische kleuren en vormgeving.

5	In de war millimeter	Misverstand legenda millimeter/centimeter.
6	Legenda	Opmerking over legenda.
7	Nummers	Quantitatief onderbouwen ter ondersteuning.
8	Uitbreiding Kaarten	Over toevoegen andere typen en versies kaarten

Appendix E

Original Visual Maps in Dutch

This Appendix contains the four original visual maps, including the Introduction Map and the Overview-Map, that have been provided to the interviewees during the 14 semi-structured interviews. The interviews were conducted online, and all Maps were combined in a pdf file. The screen with the pdf file was shared via Microsoft Teams. The interviewer could move between the pages.

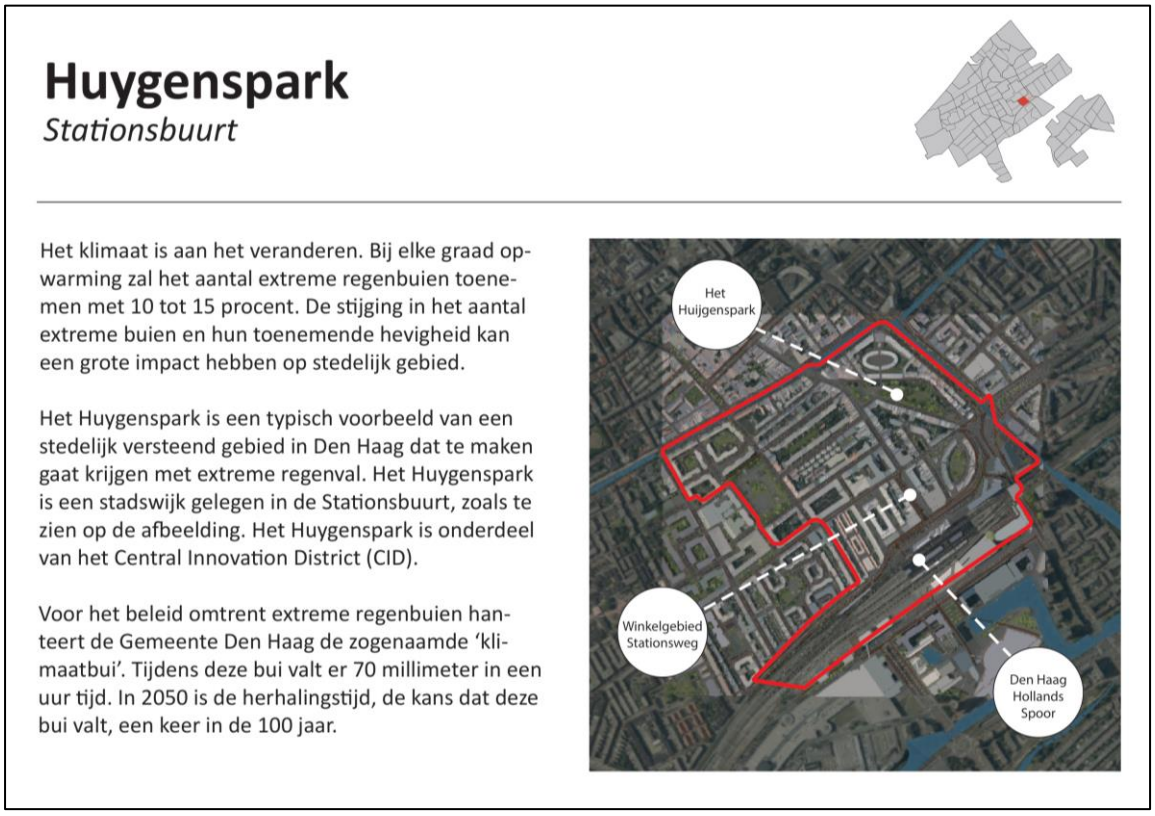

Figure 44: First map that gives an introduction to the Huygenspark

Wateroverlast door klimaatbui

Extreme regenval veroorzaakt wateroverlast, gevaarlijke situaties en schade. Wateroverlast in het Huygenspark is bij extreme buien niet te voorkomen. De meeste van de huidige riolen zijn niet gebouwd om hevige regenval aan te kunnen. Het is daarom niet de vraag of, maar vooral waar de wateroverlast zal optreden, en welke gevolgen te verwachten zijn.

De onderstaande kaart geeft inzicht in de wateroverlast in het Huygenspark na een extreme bui van 70 millimeter.

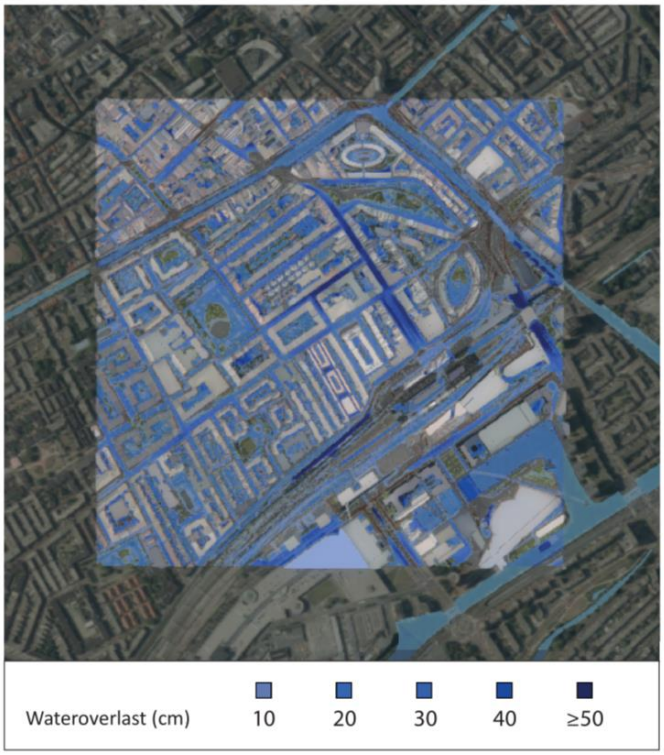

Figure 45: Map 1: 'Water Nuisance caused by Climate Rain Shower'

Wegen niet begaanbaar voor veiligheidsdiensten

Mensenlevens zullen verloren gaan als veiligheidsdiensten, zoals brandweren en ambulances, niet meer door de straten kunnen. Dit gebeurt al bij 30 centimeter water op straat. Het niet kunnen bereiken van zieken en gewonden moet ten alle tijden worden voorkomen en wordt daarom gezien als kritiek omslagpunt in de Gemeente Den Haag.

De kaart geeft inzicht voor welke buien de wegen niet meer begaanbaar zijn voor veiligheidsdiensten.

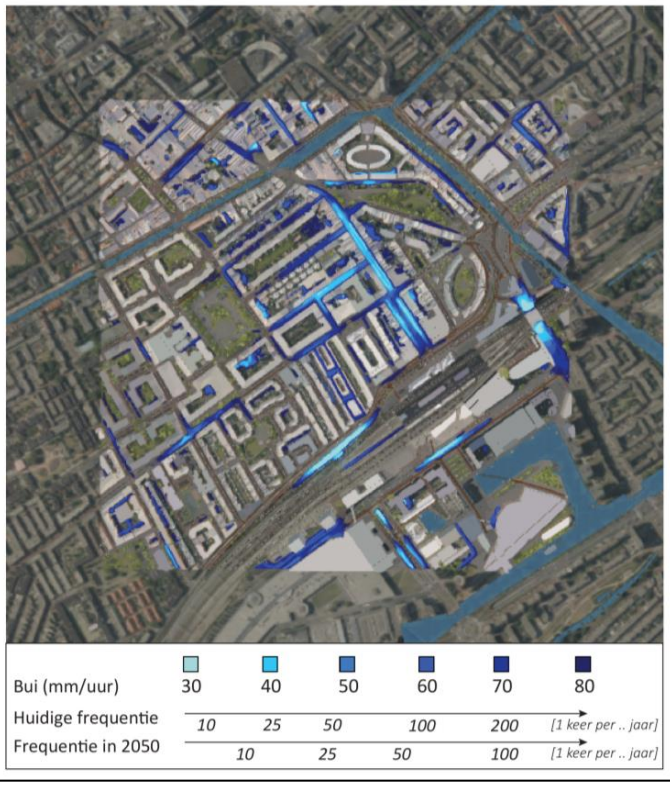

Figure 46: Map 2: 'Roads not accessible for emergency services'

Kansen tot ontwikkelen waterrobuuste wijk

De ontwikkelingsvisie voor het Huygenspark, als onderdeel van het CID, is om over 20 jaar een duurzame leefomgeving te zijn. Door een hoge concentratie van private woningen en voorzieningen is een transitie in de openbare buitenruimte essentieel om dit te bereiken. Door een slimme combinatie van meer groen en het lokaal vasthouden en bergen van water wordt het Huygenspark niet alleen bestendig tegen extreme regenbuien, maar wordt het ook een buurt dat uitnodigt tot wandelen en ontmoet.

De onderstaande kaart geeft inzicht in waar de kansen liggen om het Huygenspark waterrobuust te maken.

Figure 47: Map 3: Chances to develop a water robust neighbourhood

Herstructurering kansen voor een waterrobuuste wijk

Bij het renoveren of vernieuwen van het riool is het essentieel om ook de kansen te pakken om wateroverlast te voorkomen. Door meer groen en het lokaal vasthouden en bergen van water verbetert het watersysteem en zal wateroverlast en schade tijdens piekbuien worden voorkomen. Dit zal bijdragen aan de ambitie opgesteld in het Delta Programma om klimaatbestendig te zijn voor 2050.

De kaart geeft inzicht waar het riool op een termijn van 5 tot 15 jaar wordt aangepakt en waar de kansen liggen om het Huygenspark waterrobuust te maken.

Figure 48: Map 4: 'Restructuring chances for a water robust neighbourhood'

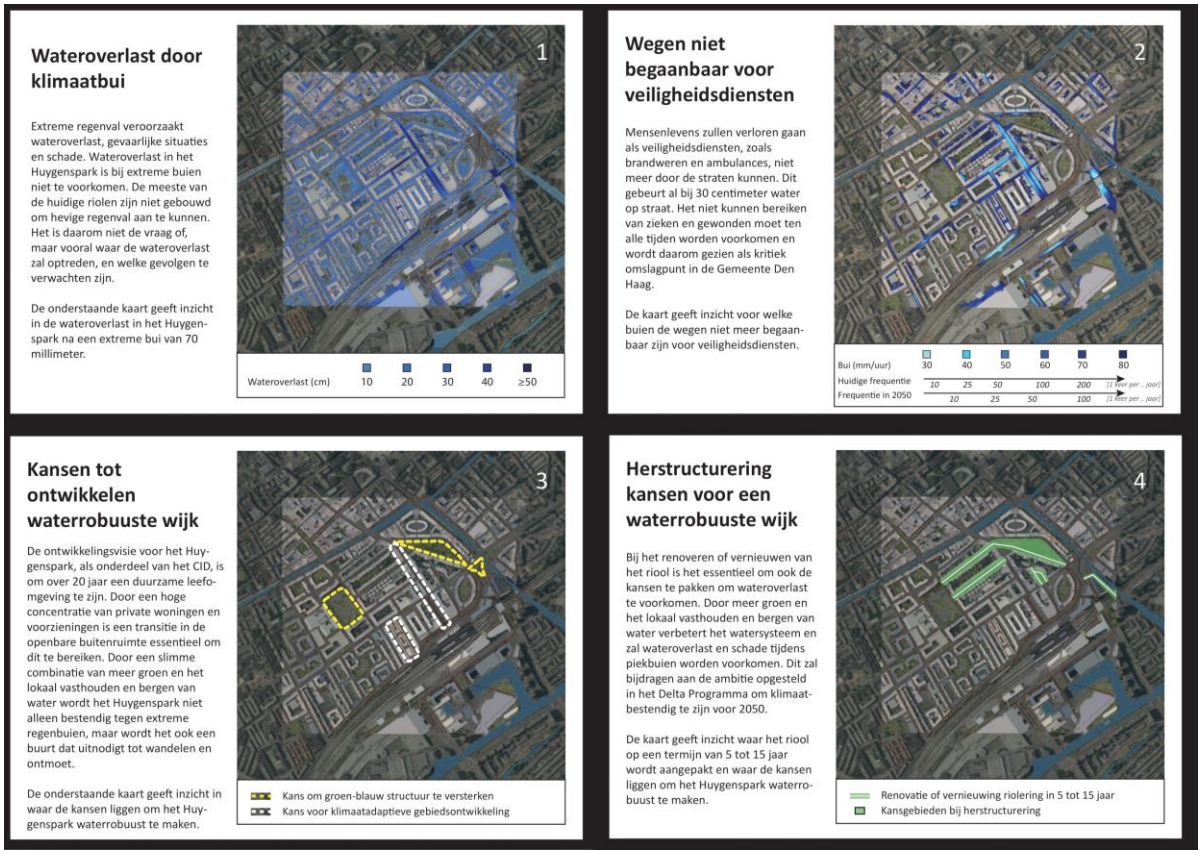

Figure 49: Final map showing the overview of all four maps. This was used during the discussion on interactions with colleagues

Appendix F

Visual Representation Results

This Appendix contains the graphical comments made by the fourteen interviewees. Only the comments that have been mentioned by at least two interviewees have been shown.

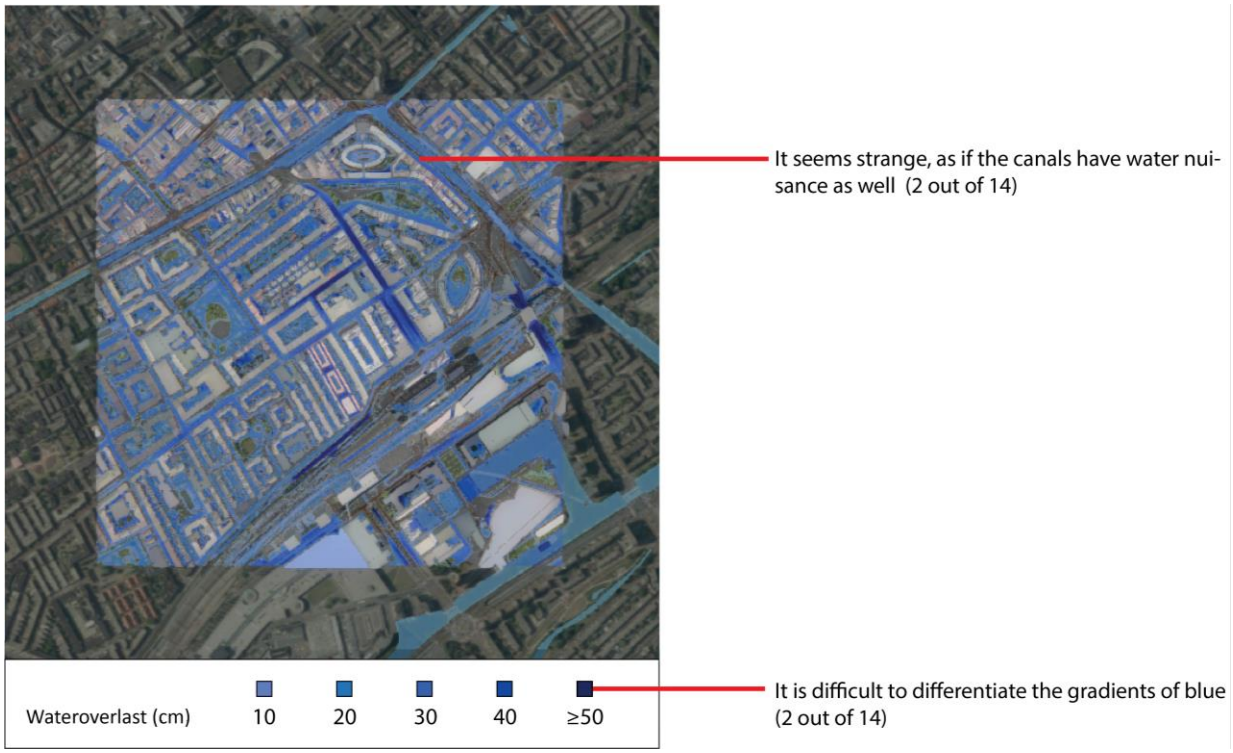

Figure 50: Graphical Remarks on Map 1

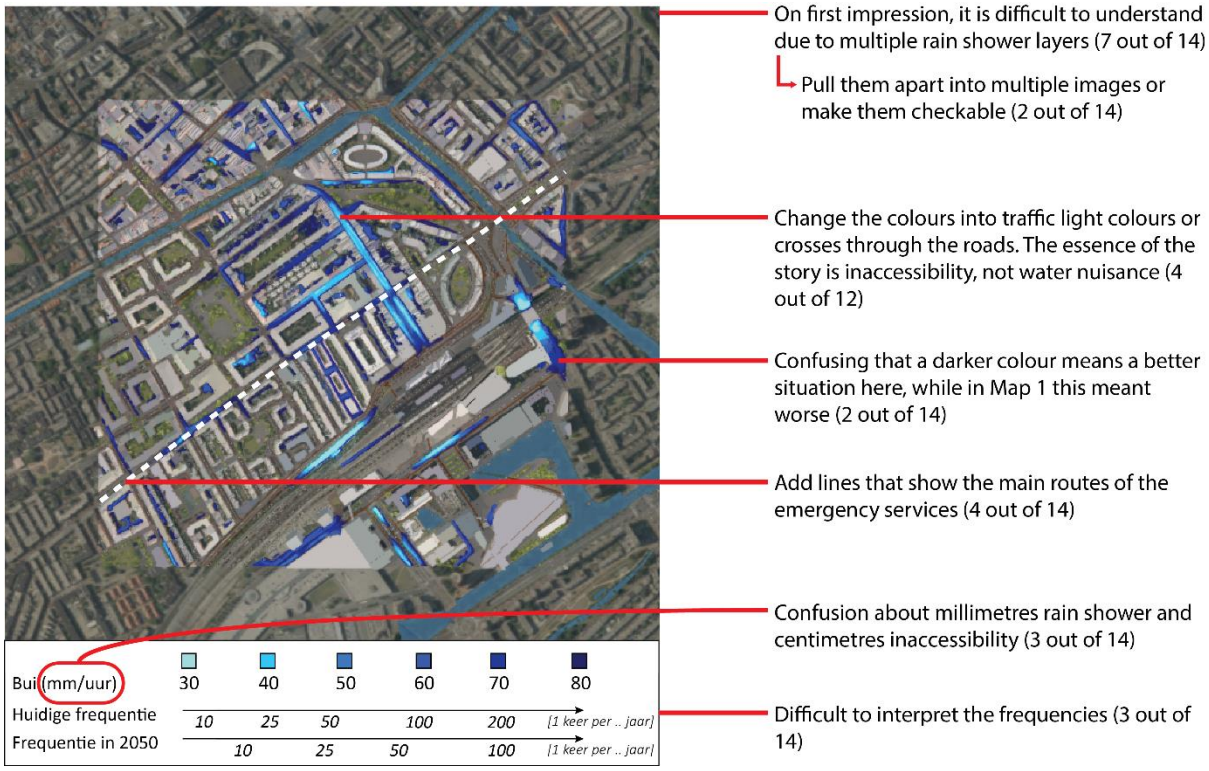

Figure 51: Graphical Remarks on Map 2

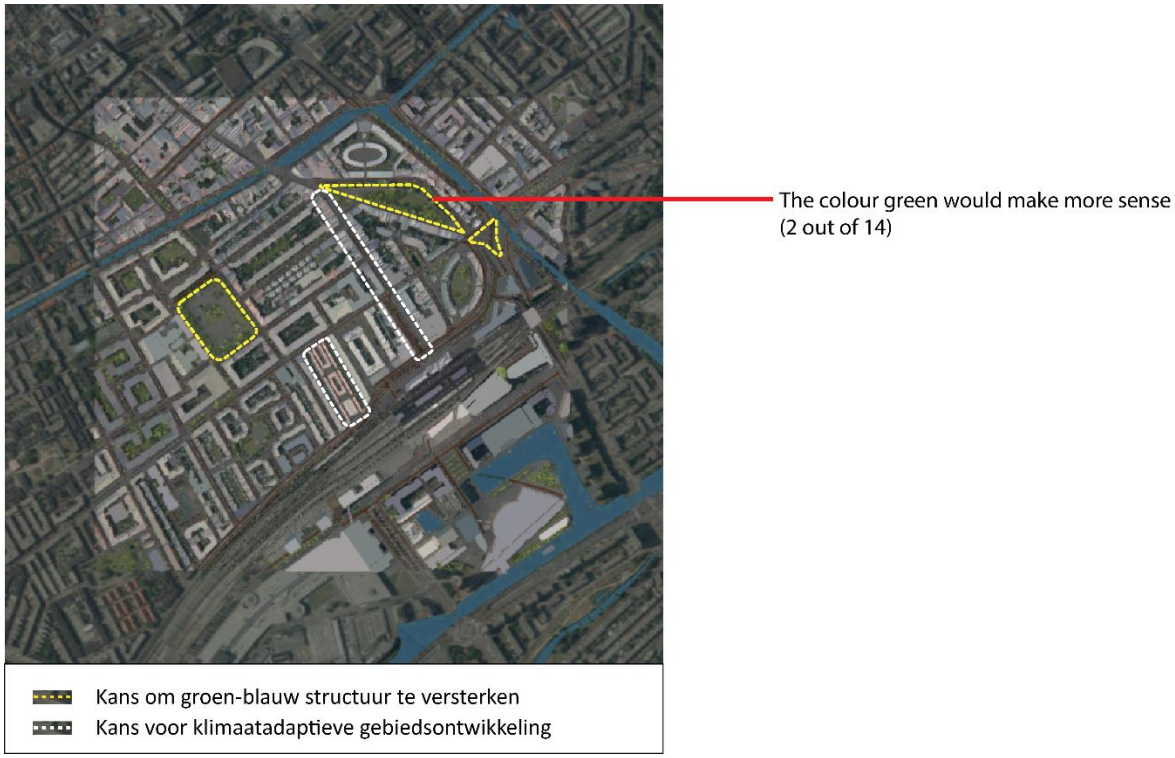

Figure 52: Graphical Remarks on Map 3

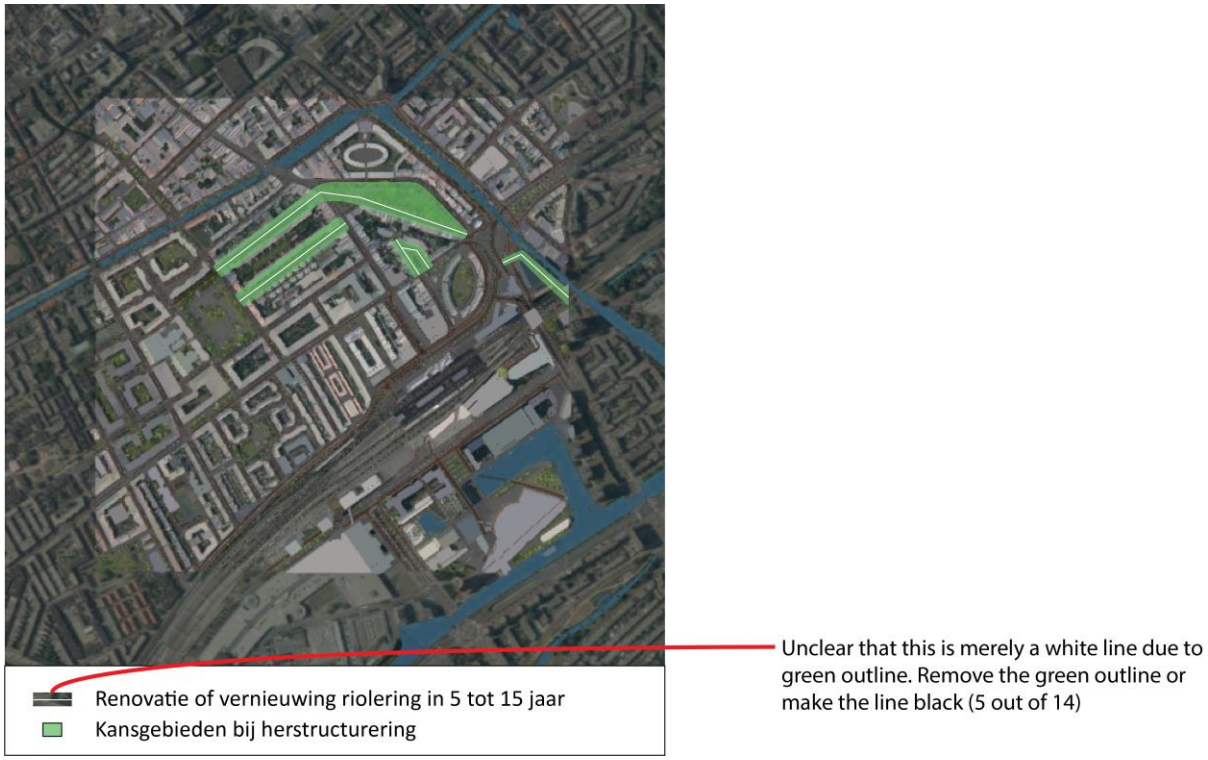

Figure 53: Graphical Remarks on Map 4