THE ADOPTION OF SUDS: A COMPARATIVE STUDY ON THE MAINSTREAMING IN MID-SIZED AND LARGE MUNICIPALITIES

A COMPARATIVE ANALYSIS ON TWO CASE STUDIES TAKING PLACE IN THE MUNICIPALITY OF ROTTERDAM AND CAPELLE AAN DEN IJSSEL DESCRIBING HARDSHIPS TO WIDE-SCALE ADOPTION OF SUDS

by Brahmanand Goerdat

In partial fulfillment of the requirements for the degree of
Master of Science in Civil engineering at the Delft University of Technology

To be defended January the 20th of 2022

Supervisors:

Dr. E. Mostert,	TU Delft- Water Resources Management (Chair)
Dr. Ir. M. Rutten,	TU Delft- Water Resources Management
Drs. Ir. E. Minkman	TU Delft - Organisation and Governance
Ir. E. Buist,	TU Delft - VPdelta
M. R. Van Roijen,	TU Delft - VPdelta

TU Delft Delft University of Technology

VPdelta DUTCH WATER INNOVATIONS

"You can't mastermind everything, you'll go crazy. Just show up and play."

Eric Clapton

CONTENTS

ACKNOWLEDGEMENTS

This document marks the last point in my study career, the fulfillment of the last requirement for obtaining my master's degree in Civil Engineering at the TU Delft. I have experienced the writing of my thesis as a challenging but yet magnificent period in my life. I dedicate this chapter to the people that have supported me throughout this journey.

First of all, I would like to sincerely express my gratitude to my supervisors. The meetings have always been very helpful in guiding me in the right direction. Erik, you've been my daily supervisor and chairman for my full thesis. I want to thank you for the time you have taken to listen to me and the provisioning of feedback. I've thoroughly enjoyed these meetings due to the relaxed and informal setting. Robert and Emilie, you guys have introduced me to this topic together with Erik. Your support has helped me a lot to gain insights into this field and by helping me to connect with the right people. I want to thank you for your availability for supporting me on this journey. Martine and Elle you have given me critical and valuable feedback at the main meetings that we've had. Once again, thank you for your guidance.
This project would not have been possible without the participation of those in the empirical research. especially with the situation of the pandemic at the time, I did perceive this as a pleasant experience. I've been welcomed with open arms to learn about the implementation process by all participants. Thank you for sharing your experiences, it would not have been possible without your help and input.

Finally, I would like to express my gratitude to my mom, dad, and brother who have been supporting and believing in me throughout the past year. Not to forget, my friends at the faculty have made the time around my program very enjoyable. I want to especially thank Mike, Marvin, Ruben & Abdul. This past year, given the circumstances, we spent a lot of time studying online and on-campus while making the best of it. These study sessions and chatter have made this period significantly more bearable, I will cherish these moments.

Brahmanand Goerdat
Delft, January 2022

ABSTRACT

This document presents a comparative analysis of the mainstreaming process of SuDS in the Netherlands between different sized municipalities. Different factors which facilitate or hinder the mainstreaming process in those municipalities have been identified. The results indicate that strategies, slack resources, policies, and experts may be factors of difference. Additionally, knowledge-sharing concerning SuDS between municipalities leaves room to be improved.

The research presented in this document presents a comparative analysis of the mainstreaming process of Sustainable Urban Drainage Systems (SuDS) in mid-sized and large municipalities in the Netherlands. As a result of the extreme weather conditions presented by the STOWA, deteriorating sewers, and the increase of paved areas in urban environments, alternative solutions (i.e. SuDS) are becoming more relevant. However, the adoption of these innovations is still rather slow. Answers are sought by different scholars, however, for the Netherlands research remains limited. SuDS that are implemented in public space fall under the responsibility of the municipalities. Hence, recent studies have highlighted factors in the implementation process of SuDS for municipalities in general. The biggest municipalities seem to always be leading in research and disparities in how different organizations perceive influencing factors of the implementation process have not been studied yet.

The research objective of this thesis is to find to which extent the perceived factors in the mainstreaming process between different sized municipalities differ.

The methodology consists of a literature review, two case studies, and a focus group. The literature review concerned transition theory which was applied to climate adaptation. A conceptual framework has been developed that describes the mainstreaming process. Different theories were combined in this framework: the Mainstreaming model, four-A framework, Governance Capacity Framework, multi-level perspective.
The empirical research applied consists of case studies that have taken place in two Dutch municipalities: Rotterdam and Capelle aan den IJssel. The case studies considered were projects that implemented a new concept for the first time. The main criteria for the selection were the size of the municipalities and their (geo)hydrological boundary conditions. A comparison was made between the results of both studies and cross-checked in a focus group. The data in the case studies were collected through semi-structured interviews and documentation. The semi-structured interviews were based on themes identified in the conceptual framework. The semi-structured interviews were conducted via Microsoft Teams. Examples of questions that were asked were: "What were the main drivers for the project in your city?" and "Do you find that propositions of innovations are well received in your department?".
The interviewees were part of these case studies and sampled through a stakeholder diagram and snowball effects. In total 10 participants were interviewed which were part of the case studies. To increase the validation of the case study results, different municipalities were invited to participate in a focus group to evaluate how they identified with the findings. This focus group consisted out

of two mid-sized and two large municipalities. The oral data was analyzed through the principles of Atlas-TI.

The findings of the study imply that the mid-sized municipalities differ from larger municipalities mainly on three factors:

- They still have to form climate-adaptive strategies.
- Their allocated budgets are inferior
- They lack policies that allow for alternative methods as opposed to traditional sewer management.
- They lack climate-adaptive experts who are actively involved in projects.

Furthermore, it was found that knowledge sharing of pilot experiments should be pursued more actively to facilitate the adoption of SuDS. In addition, this knowledge is now mostly catered to engineers, developers, and policymakers. For which it was found that to facilitate adoption, the involvement of asset managers should be pursued too.
The research is of conceptual use and is of use for multiple groups. The problem statement has been initiated by VPdelta which is a valorization program that bridges innovative SuDS to the market. It is therefore interesting for them to gain insights into the barriers and driving factors on the side of the clients. For scholars, the research gap of heterogeneity between municipalities has been explored which helps to understand the problem from different perspectives. Lastly, it may be interesting for mid-sized municipalities as recommendations are formed for what they can do to become more climate adaptive.

ABBREVIATIONS

- BGI - Blue-green indicators
- DPRA - Delta programma ruimtelijke adapatie (Delta program spatial adaptation)
- HHv Delfland - Hoogheemraadschap van Delfland
- IR - Impuls regulation
- LIUDD - low impact urban design and development
- MSP - Municipal Sewer Plan
- SuDS - Sustainable urban drainage systems
- UWB - Urban Water Buffer
- UWM - Urban Watermanagement
- WSUD - Water sensitive urban design

List of Figures

List of Tables

1

INTRODUCTION

This chapter describes the context of the problem concerning this research, simply the mainstreaming process of sustainable urban drainage systems. This is followed by the research gap, objective, and questions. Lastly, the scope of the study is elaborated to clarify the perspective from which the problem is analyzed.

1.1. PROBLEM DESCRIPTION

The need for a more integrated and sustainable approach for urban water management practice is widely acknowledged. Climate change in combination with urbanization and deteriorating infrastructure will result in more floods and droughts and more water quality problems. (Zimmerman et al., 2008; Drosou et al., 2019 & Suleiman, 2021).

For urban environments, climate change will result in more extreme weather. STOWA (2019) has predicted an increase of magnitude and frequency in extreme rainfall events in all of their scenarios for the Netherlands. The current sewer systems are not designed for these loads, hence the probability of pluvial flooding fis likely to increase. Additionally, urbanization is causing an over-use of 'grey constructions', such as concrete and asphalt which create impermeable surfaces that lead to higher peak loads on the current system and less infiltration capacity (Nguyen et al., 2019). Different municipalities have adopted the transition from combined to seperated sewers in their municipal sewer plans (e.g. Waternet, 2016 & Gemeente Rotterdam, 2015). The need for alternative decentralized solutions is growing, due to the competitiveness for the space beneath the surface for different ducts, wiring, greenery, and other comparable infrastructure.

All of the stressors above underline the urgency for changing how the rainwater is managed in urban environments and a revision of the storm water systems through new approaches and practices that require a transition from the current piped systems (Cettner et al. 2014; Suleiman 2021; Roy et al. 2008; Kiparsky et al. 2013 & Van der Brugge and De Graaf 2010). From a technological perspective and given the uncertainty concerning the speed and magnitude of climate change, there is a need for more flexible systems to be incorporated in the urban water management sector.

Three different approaches for such systems are listed by Van der Brugge and De Graaf (2010):

- Improvement of the current urban water system by developing new concepts that increase the efficiency of the system
- A complete renovation of the current water system or a complete renewal
- Experimenting with different combinations, which consist of multi-functional systems (i.e. additional decentralized drainage systems).

The first and third options in particular are interesting, as new innovations have been introduced over the past few decades that correspond to the challenges that urban water systems are facing (Cettner et al., 2014). The second option would come with significantly high costs, which would be least desirable (Van der Brugge and De Graaf, 2010). There are different approaches that complement the initial system by lowering their (peak) loads, of which in this thesis the focus will be on Sustainable Urban Drainage Systems (SuDS). In this report, the term mainly refers to innovations that mitigate pluvial flooding, by bringing water management and (green) infrastructure together to maintain or improve natural water cycles.
SuDS solutions work on the principle of moving rainwater, enhancing its infiltration and altering its runoff speed towards the endpoint that drains off the land into waterways and corridors. The water is intermediately stored in buffering spaces, where it can be slowly released for drainage into the soil or canals. Examples of SuDS are: ponds, wetlands, porous pavements, swales for detention, open canals, dams, green roofs, walls, and bio-retention systems (Hamann et al., 2020; Drosou et al., 2019).

Strategies for both climate mitigation and adaptation are important for improving the resilience of urban environments towards climate change (Stead, 2014). SuDS are the general solutions that form climate adaptation. Hence, a significant part of the study will delve into climate adaptive thinking. Adaptation strategies in this thesis relate to all proactive and planned adaptation strategies, measures, and options to manage the impacts.
Currently, multiple innovations regarding SuDS are being developed in cooperation with VPdelta which is a valorization program in Delft. In their field labs, entrepreneurs can demonstrate and develop their products further while spreading their knowledge to neighbors and potential clients. These innovations can be of high interest to municipalities and their adaptation goals. A widely recognized problem is that these innovations are struggling to be widely implemented, moreover past their demo and pilot phases. This has been pointed out by VPdelta and is backed by different scientific articles (Uittenbroek, 2014; Veldkamp, 2020; Roy et al., 2008; Kiparsky et al., 2013 & Drosou et al., 2019).

1.2. RESEARCH GAP

First of all, it should be noted that the clients of the startups providing SuDS, on a larger scale are municipalities in The Netherlands. This logically follows from the Dutch law, where it is stated that municipalities are responsible for the procedures concerning urban sewer management and discharge of rainfall on public space (Waterwet art. 3.5, 2021) & (Waterwet art. 3.6, 2021). In addition, the treatment of wastewater in urban environments is the responsibility of the waterboards (Waterwet art. 3.4 lid 1 & 2, 2021). In the situation of combined sewer systems, this responsibility could shift towards the municipalities after a mutual agreement with the waterboards (Waterwet art. 3.4 lid 1 & 2, 2021). Therefore, municipalities in the Netherlands are taking responsibility concerning the incorporation of plans to transition towards more resilient, sustainable, and better performing urban water systems (e.g. Waternet, 2016; Gemeente Rotterdam, 2020).

Due to the growing urgency for the implementation of climate adaptation, discussions are shifting towards the question of how to operationalize climate adaptation in practice. As a result of this question becoming more relevant, there are multiple policies that have emerged from the international to local level within the Netherlands. An early example was the National Adaptation Strategy (NAS), which was launched in 2007. It focused on different topics besides urban watermanagement. The most recent example being the National Deltaprogram (2017 - present) , which intends to promote knowledge generation on climate adaptation.
Similarly, numerous scholars have focused on the identification of associated factors to implementation (Biesbroek et al., 2011). This lack of implementation can be explained by two different domains: 1) The technical perspective and 2) The socio-institutional perspective (Brown and Farrelly, 2009 & Kiparsky et al., 2013). For the technical domain, it is readily known that the maintenance and lifespan of SuDS form the most important barriers to implementation (Veldkamp, 2020). Veldkamp (2020) has conducted 67 infiltration experiments for permeable pavement, of which 43 out of 67 infiltration tests showed infiltration values above 194mm/h (National performance requirement). A second finding from this study is that the correct maintenance can increase the infiltration speed up to 380%. A different study conducted by Boogaard and Lucke (2019) found that only 4 out of 16 of their chosen permeable pavements showed infiltration values of above 194 mm/h. However, these are snapshots in the short-term, more knowledge must be gathered on the long-term functioning.

The second domain is rather related to the transition that occurs within municipalities themselves. For the second domain, various terms are used such as socio-technical, institutional, organizational, or governance-related factors. This domain concerns the changes which municipalities have to process internally. In most cases multiple governance layers and a variety of stakeholders, sectors and policies are involved, which all have their own necessities (Koop et al., 2017 & Segrave et al., 2014). A widely recognized strategy for climate change adaptation by municipalities is the use of mainstreaming, which is synonymous with standardization. Mainstreaming implies the integration of climate adaptation within the current domains, rather than creating a new distinct department and policy domain for climate adaptation that functions in spite of the current departments (Uittenbroek et al., 2013).
This style of transitioning does come with associated factors that affect this process that may function as barriers or drivers. Examples of the barriers from institutional perspectives span across public awareness, knowledge, capacities and skills, and costs (Van der Brugge, 2009). Frameworks for organizing those barriers are depicted in different literature (Cettner et al., 2014; Van der Brugge and De Graaf, 2010; Brown and Farrelly, 2009; Koop et al., 2017; Suleiman, 2021; Qiao et al., 2018 & Nguyen et al., 2019).
Furthermore, there are different frameworks that depict transitions at theoretical levels such as the multi-level perspective (Geels, 2002a; 2012) and subdivide transitions in different phases (e.g. Uittenbroek et al., 2013 & Rotmans et al., 2001). At practitioners level, the answer is less clear (Brodnik et al., 2017), which concerns the internal communication and structure of the organizations with the ultimate responsibility (i.e municipalities).

There are many causes that can lead to complexity, uncertainty, and disagreement. As a consequence of these implications, there isn't one particular best approach to address governance challenges (Cettner et al., 2014 & Koop et al., 2017). What is needed is an iterative process that works towards a long-term vision with different intermittent targets to anticipate changing situations and adapt to the barriers in each phase (Koop et al., 2017).

One notion which has not yet been taken into consideration within research in the implementation

process is that municipalities come in different sizes and structures. Hence, not all of the decision-making within those municipalities is done in similar manner. From a theoretical standpoint, these notions relate to governance capacity which can clarify differences between organizations (Koop et al., 2017).
There is a lot of research available, even for the Netherlands itself, concerning barriers of implementation (e.g. De Graaf et al., 2009; CAS, 2021).
However, all studies (also within the Netherlands) focus on larger municipalities or generalization of municipalities, which implies that there a certain level of homogeneity is assumed between larger and smaller sized municipalities. Moreover, different aspects are named without taking into consideration different background scenarios. Research in this area can lead to more insights into the background and context of climate adaptation on a local level.
Additionally, research has been done for small cities and predominantly smaller coastal towns (Hamin et al., 2014; Martin et al., 2021 & Lehmann et al., 2021). These articles seem to focus on smaller towns regarding climate change adaptation, however, they are scoped towards sea-level rise rather than fluvial flooding in urban. The times of publication could imply that interest is growing for this topic, however, the citation rate remains very low for now.
General statistics read that there are 355 municipalities in the Netherlands, of which the majority of area and inhabitants are divided over the mid-sized and smaller municipalities, opposed to the G4 (Amsterdam, The Hague, Rotterdam, and Utrecht) which are usually analyzed. Hence it is of interest to take into consideration their perception of socio-institutional barriers and drivers as this opens a new field of knowledge to the parties interested. This thesis will explore the gap in lack of homogeneity between municipalities of different sizes and assess this using different theoretical frameworks at the practitioners level by two case studies in two different sized municipalities.

1.3. RELEVANCE OF RESEARCH

This research has been established according to a first move by VPdelta and the main supervisor. The initial issue was the low uptake of innovative SuDS, for which insights were sought. By performing an initial literature review the research gap came forward. The results of this study offer insights for different parties: scholars, municipalities, and innovative entrepreneurs. As only larger municipalities have lead to the generalizations up until now, a bias may be present in current research. The results of this study offer insights in these differences through approaching this in gap in structured manner. For scholars, this is specifically the evaluation of the mainstreaming process by exploring specific cases in-depth from a practical perspective opposed to a generalized approach that leaves out the context (Koop et al., 2017 & Adem Esmail and Suleiman, 2020).
Current literature, did not take into consideration all of the different phases of mainstreaming in depth. When they did it was mostly a summation of factors. This is important, however, does not seek a reason for why these barriers occur. Furthermore, research till now has not yet described the mainstreaming process with a complete framework. In this study a framework is proposed that takes into consideration many phases, for which scholars may be challenged to find additions, which was still missing in current literature (Uittenbroek, 2016).

For VPdelta, from the entrepreneurial perspective, the results of this study will be of higher relevance as they gain insights in the mainstreaming process which concerns successful implementation of innovations that were previously on the field-labs. The results are meant to be helpful for long term up-scaling process, hence insight in a larger arsenal of clients and the practicalities and thought-process are of high relevance to both. For their processes, from the study findings they may come to new insights in strategies that can be helpful for up-scaling.

As climate change is a growing topic of interest for municipalities, those that have not yet established climate adaptive measures may benefit from learning from the findings of this study. In addition, the lack of municipalities outside of the G4 being represented in scholarly research, presents an opportunity of academic attention for this group that has been left out.

1.4. RESEARCH OBJECTIVE

The main research question is to tackle the issue of heterogeneity concerning municipalities, it is stated as follows:

To what extent does mainstream capacity towards implementing sustainable urban drainage innovations between different sized municipalities in the Netherlands differ?

1.5. RESEARCH QUESTIONS

To fulfill the research objective it is important to answer the following questions:

1. How can the mainstreaming process be described?
2. Which factors are important to consider in the mainstreaming process?
3. What does the decision-making procedure look like within municipalities?
4. What are the factors perceived by different sized municipalities that facilitate or inhibit the implementation of SuDS?
5. Which recommendations can follow regarding improvement of the mainstreaming process for mid-sized municipalities?

1.6. SCOPE

The scope is best described by three factors, pluvial flooding, the organizational level, and geographical level. A large transition is currently ongoing in the Netherlands, which does not only involve water stress, but also heat stress and sustainability regarding energy consumption. In this thesis, the focus will be on pluvial flooding occurring due to rainfall events, which concerns innovations tackling urban drainage problems. There are different types of dimensions that describe the implementation of SuDS, the technological dimension, and the socio-institutional dimension. Of which the latter will be explored further in this thesis.
Governmental bodies span in the range from Global, European, National, Regional and Local scale. There are different authorities within the Netherlands (i.e. National, provincial, municipal, and water boards). They are interlinked and have an influence on the municipalities, but as stated before the overall responsibility of urban drainage of rainfall water remains with the municipality. Since startups are interested in wide-scaled adoption, the full mainstreaming process of relatively new innovations is taken into consideration.

On a geographical level, this study applies only to the Netherlands. Two different municipalities are chosen for the case studies, namely Capelle aan de IJssel and Rotterdam. Capelle aan de IJssel is a mid-sized municipality, with ±65000 inhabitants opposed to Rotterdam which belongs to the G4 (>300.000 inhabitants). The choice of those municipalities is determined by convenience and their uniqueness. Rotterdam has naturally high groundwater levels and a silty/clay underground, therefore they have been incorporating water- and climate adaptive measures since the early 2000s. Hence for reasons mentioned earlier, the space in the underground is becoming scarce hence alternatives are interesting. Capelle aan de IJssel is located right next to Rotterdam and has a similar

underground, which makes it interesting as they have the same technical boundary conditions. The case study findings have been discussed in a focus group with different municipalities.

1.7. READING GUIDE

The thesis consists out of eight chapters, of which this Chapter 1 has introduced the problem and objective of the thesis. Chapter 2 consists of a literature review, for which the sections describe transition theory and scope towards a proposed framework for evaluation of mainstreaming in Chapter 3. The literature involved in this chapter is meant for explaining the findings of the case studies. The proposed rfamework will be used as a means to reach the objective, additionally, it may be tested and altered to the findings of the study. In Chapter 4, the methodology is explained which is used for the case studies to come up with the desired results. The methodology and framework are applied in chapters 5 and 6, where, in each chapter respectively a case study is carried out per municipality. In Chapter 7, a comparative analysis is presented of the results together with the findings of the focus group. municipalities relate in practice. Chapter 8 presents the conclusion.

2

LITERATURE REVIEW

In this chapter the literature review is presented. It consists of theory that is relevant for understanding the further research. First, the terminology of 'sustainable urban water systems' (SuDS) is elaborated, followed by a description of transitioning to the adaptation of new technologies (sections 2.1 & 2.2. This transitioning section is divided into an elaboration on transition theory, which shows the adaptation stages an (urban-water) innovation has to go through. Section 2.2.2 explains the multi-level perspective (MLP), which shows how an innovation adapted within the regime and how it contributes to the scope. The methods of adaption for the municipalities are explained under section 2.3. Finally, a minor elaboration is provided on organizational size and the adoption of change.

2.1. SUSTAINABLE URBAN WATER MANAGEMENT TERMINOLOGY

There are many different terms that describe innovative technologies related to sustainable urban water management as its popularity is increasing. Fletcher et al. (2015) identified many different terms which are used in literature to describe similar concepts. This difference in terminology was mostly based on geographical location and can be a cause for confusion.

One of those terminologies used in North America and New Zealand is Low Impact Development (LID), which is an approach to minimize the costs of stormwater management by taking a design that mimics natural drainage functions (Fletcher et al., 2015). However, due to the lack of the word water, this term is used for many other sectors as well. A variation of this concerning more urban environments is the Low Impact Urban Design and Development (LIUDD) (Fletcher et al., 2015). This term is particularly used in New Zealand, in the grand scheme of urban development it focuses on pollution prevention rather than the management of flows. Water Sensitive Urban Design and Integrated Urban Water Management are all-around terms referring to the full water balance water quality maintenance and water conservation encouragement in urban areas (Fletcher et al., 2015). Another concept that is introduced concerning multiple aspects in the sustainability transition is the concept of Blue-Green Infrastructure (BGI's), it is used to describe (semi-)natural infrastructure that helps to reduce the risk of harmful natural events in such a way that it contributes to ecosystem services (Deely et al., 2020). Furthermore, in China, the term Sponge Cities (SC) is used to describe another urban water management strategy. It encompasses urban water resourcing, ecological water management, green infrastructure and permeable pavement (Nguyen et al., 2019).

Sustainable Urban Drainage Systems (SuDS) is a term that originates from the UK and is mainly

used in Europe, it consists of a range of technologies that are used for stormwater drainage and form an alternative or addition to inertial piped systems (Fletcher et al., 2015). Their Australian/American counterpart is named the water sensitive urban design (WSUD), which is another tool that describes ponding, infiltration, and harvesting of water at the source, while enhancing evaporation, groundwater recharge, and re-use of stormwater (Roy et al., 2008). The general thought behind SuDS is to enhance or mimic the natural drainage of a site, which overlaps in that regard to LID and BGIs. Besides the factor of de-loading the main system, they offer other benefits such as: pollutant removal, quality of urban space, livability, support of ecosystems, green infrastructure, cooling, and an additional water supply (Cettner et al., 2014).

The term SuDS seems to encompass most of the technologies described and those concerned in the thesis, thus SuDS will be used as it fits the core technology that offers an alternative/contribution to current piped systems. SuDS are often categorized into green roofs, permeable surface, infiltration trenches, wales, shallow drainage channels, detention basins, ponds, wetlands, flooding parks (Arahuetes and Olcina Cantos, 2019). They can be classified in systems that deal with the runoff at the surface or in systems downstream of the runoff source (e.g. systems that enable re-use of water by incorporating treatment). Different SuDS are available for private and public properties, of which this thesis will focus on the public property which falls under the liability of the municipality. A difference is that for private properties the main investment comes from the private actor, depending on whether subsidies are applicable through the municipality. Examples of SuDS that have been implemented on public property are displayed in Figure 2.1.

Figure 2.1: Left: Urban Rainshell in test phase by EWB (The Rainshell has been implemented outside of the test phase); Top: Water square Rotterdam; Bottom: Conceptual Bluebloq patch in Madrid by Field factors. (Sources: https://fieldfactors.com/ & https://thegreenvillage.org/opschaling-urban-rainshell-naar-gemeente-zoeterwoude/urban-rainshell/)

2.2. TRANSITION MODEL THAT DESCRIBES A HIGHER ADOPTION RATE OF SUDS

2.2.1. A DESCRIPTION OF TRANSITIONS

Technological innovations have become more prominent at modern times. Their adoption by society is well described by transition models. Rotmans et al. (2001) defines a transition as "a long continuous process of societal change during which the structure of society, or a sub-system of society, fundamentally changes. The term transition, in this case, describes a result of several processes where a system shifts towards more sustainable modes of urban stormwater management. Usually, these transitions take over 25-50 years and are characterized in multiple phases (See Figure 2.2). In addition, these transitions span across multiple domains: technological, economic, institutional , behavioral, and cultural (Kiparsky et al., 2013).

Various schemes have been proposed to categorize the innovation transition types, the typical distinction is between radical innovation and incremental innovation (Kiparsky et al., 2013). Dewar and Dutton (1986) states that radical innovations can represent "clear departures from existing practice" as opposed to making small changes to current technology (incremental changes). However, they acknowledge that this can be subjective. A plausible description of transitions is that radical and incremental changes are both part of the evolution of a technology over time (Freeman, 1994), this is displayed in Figure 2.2. The radical part is the new technology which is introduced, which is fine-tuned by learning from iterative implementation. In practice for SuDS, the incremental change would come from the end-users perspective through learning opportunities financially and performance wise (e.g. urban water managers). Marlow et al. (2013), described the transition as incremental, and found that a breakthrough of the integration of SuDS into a regime was found to be highly unlikely.

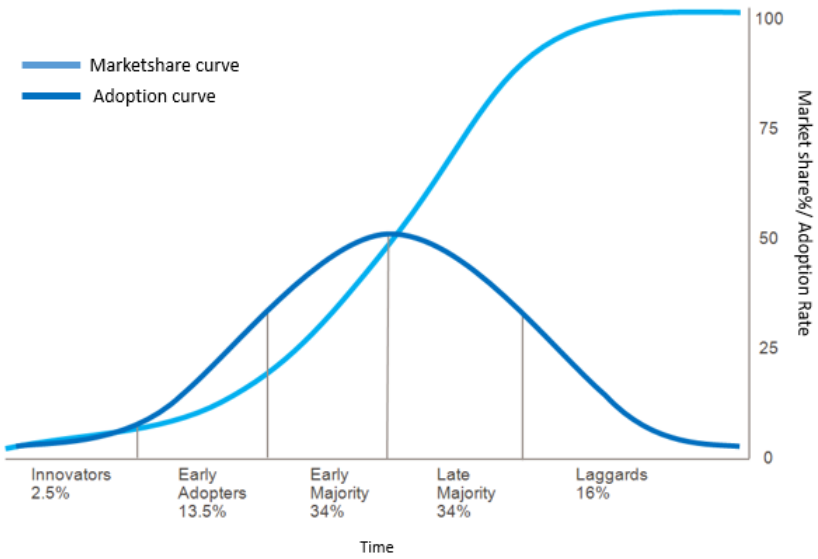

Figure 2.2: The phases of innovation adoption presented by Kiparsky et al. (2013) adapted from Rogers (2010)

Table 2.1: Description of adopter groups based on Rogers (2010) & Rogers (1971)

Adopter	Characteristics description of adopter
Innovator	Innovators are very eager to pioneer experimenting with new ideas. They are willing to take high risks, which made possible with their high financial liquidity. They are not afraid of potential setbacks, which could be due to their financial buffer. They have a high social status, which links them to science and other innovators.
Early adopter	This group is posesses the same traits as the innovators group, except they are more discreet in their choice of innovations. They are also seen as the key-group in the diffusion process of innovations. Their verdict on an innovation, is usually what the majority requires for buying-in. This is based on them having a reputation of succesfull implementation of new ideas.
Early majority	This group also plays a large factor in the diffusion between the early adopters and later majority. Their decision-making time is longer than the previous groups, as they require to thoroughly weigh their decision associated to their resources.
Late majority	This group follows adoption after most of the population has done so already, they are rather sceptical. Their actions are based on experience of earlier groups and are mostly based on the weight of system norms.
Laggard	Laggards are the last group to adopt an innovation, to the point that is not an deemed an innovation anymore. They are not only sceptic about the technology but also the previous groups.

Technology transitions require a set of institutional and social factors to be lined up correctly and often struggle for a certain period (Moore, 2018). The adoption of new technology happens at a slow take-off, the adoption is divided into phases in which respectively different types of adopters are present. Rogers (2010) established the following types of adopters: innovators, early adopters, early majority, late majority and the laggards.

In the innovator's phase, experiments take place to gain recognition for their project and prove that they are set for implementation in practice. This is followed by the early adopter's phase, usually, the innovation is implemented in practice on a pilot scale to see how it will perform in practice. Early adopters take a risk by buying in and implementing new innovations hence a slow take-off. Once the product gains recognition the early majority and late majority will buy-in, which will occur at an increasing rate until the curve flattens due to reaching market saturation.
Focusing more on the urban water management transition, Moore (2018) describes that the urban water management transition consists of six different phases towards a water sensitive city. They state that a gradual switch takes place over time from large centralized infrastructure and institutions towards an integrated infrastructure and institutional environment. Three pillars are required for this transition according to Wong and Brown (2009):

- Cities should function as water supply catchments. There should be access to a diversity of water resources which should be supplied by centralized and decentralized infrastructure
- Cities should provide ecosystem services to the built and natural environment
- Communities should be involved to create capital for sustainability and water-sensitive choices

The most critical point is in the middle of the process, where a shift occurs from a practical standpoint to one that starts to take into consideration ecosystem services, and more priority is given towards maintaining resilience and adaptation. This adaptation model is backed up by Moser and Ekstrom (2010) which states that on the short-term coping measures are implemented, followed by more substantial adjustments and eventually in the long-term a full paradigm shift.

Freeman (1994), has described a three-step linear framework that supports the adaptation curve. However, it implies that the process of adaptation is a linear process which is disparaged by Kiparsky et al. (2013). Instead, they plead that innovation should be seen as a chain of activities. A recently invented framework that supports this notion explicitly for SuDS is suggested by de Graaf-van Dinther et al. (2021), for which they propose an overview of interlinking factors that lead to a higher implementation rate (Figure 2.3). Thus this model more accurately describes the underlying mechanisms of the curve displayed in Figure 2.2, than the linear model.

Two shifts are presented in this transition, which are: 1) from stakeholder awareness (informing) towards creating awareness of the full system potential and 2) from technical functioning towards the investigation of the full system impacts.

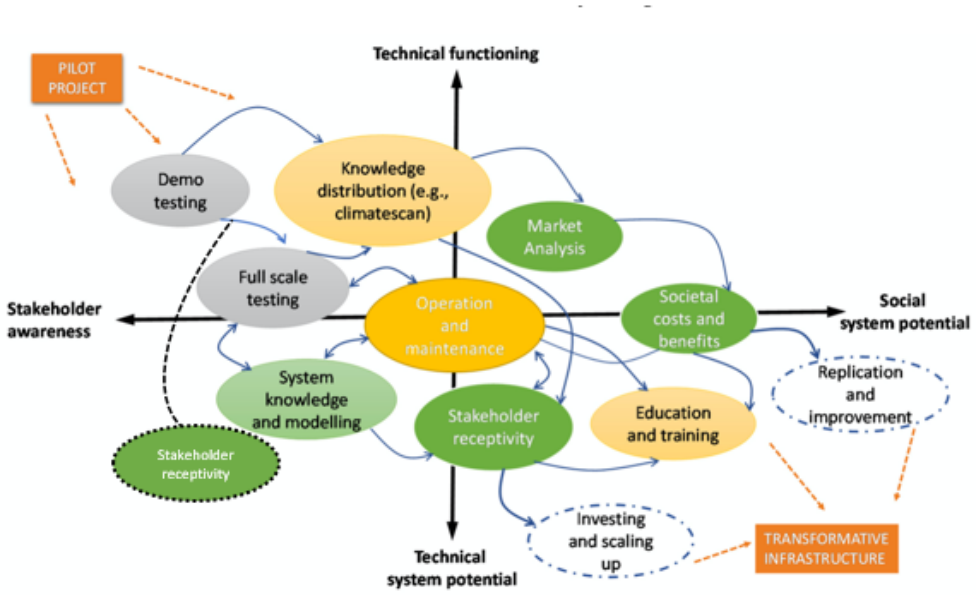

Figure 2.3: Overview of steps required for increasing the adoption rate of SuDS (Adapted from de Graaf-van Dinther et al., 2021).

Demo testing is conducted in practice at a test facility such as the Greenvillage. This could be followedup by a pilot experiment which is usually the first time an innovation is put into full-scale practice. Initially, this full-scale test is already subjected to stakeholder receptivity. This became evident from initial interviews (interviewee 1 & interviewee 4). Hence, in Figure 2.3, a stakeholder receptivity box is added with the dotted outline. From the full-scale testing, learning lessons are taken away through operation and maintenance, thus gathering more knowledge. Upon this evaluation, again stakeholder receptivity is required for replication.

2.2.2. THE MULTI-LEVEL PERSPECTIVE

Multiple authors (e.g. Kiparsky et al.; 2013, Geels, 2002b; Moore, 2018 & Suleiman, 2021) recognize the notion that technological innovation is not enough and that socio-technical dynamics need to change into new directions too. Two key terms are required when talking about institutional innovation, which are institutions and organizations. Institutions are defined as the rules, norms and practices that govern decision making (Kiparsky et al., 2013). In the Netherlands, there are different interacting levels of governing bodies, which on each level have different organizations. Organizations are collectively orientated groups (e.g. municipalities and waterboards) that are pursuing goals that are linked to external pressure. Depending on the level of governance, different boundary conditions are prevalent. Climate adaptation requires action on different levels of governing bodies, where the ones higher in the hierarchical ladder muststimulate those smaller-sized bodies by facil-

itating adaptation strategies and guidelines. Three major scales of governance are found within the Netherlands, though they form no real rigid structure as negotiation is possible and the municipalities retain a lot of freedom in their policy domain (McCarthy, 1998). The relation is characterized by indicative plans on national levels. On the provincial scale these are adopted within the regional plans and finally, on the municipal scale these are adopted on structural and local plans (McCarthy, 1998; Berry and McGreal, 2003).

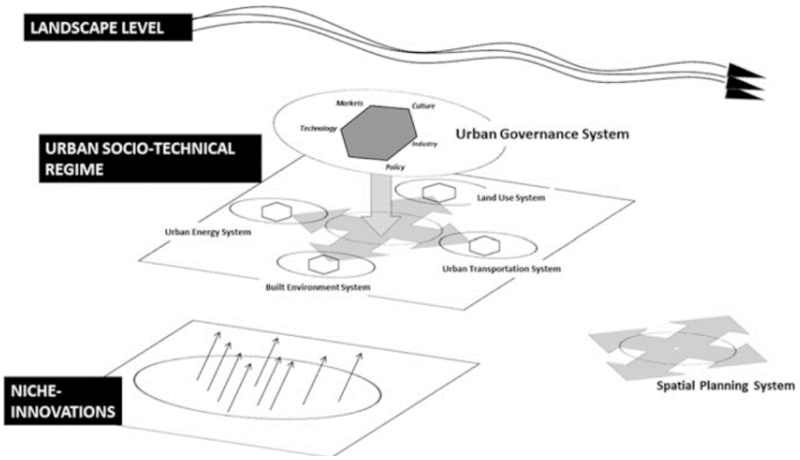

Figure 2.4: Spatial planning system linked with nested systems of the urban socio-technical regime within the MLP (Moore et al., 2018 adapted from Geels, 2012).

Rip et al. (1998) describes how a transition occurs in an urban socio-technical regime using the multi-level perspective (MLP). This concept has has been applied widely by other scholars (e.g. Moore, 2018; Geels, 2002b; Geels and Schot, 2007; Grin et al., 2010; Van der Brugge, 2009). The MLP states that transitions are put into action through three levels that interact with each other which consist of: niches, socio-institutional regimes and a landscape (See Figure 2.4) (Geels, 2002b; Rip et al., 1998). Respectively, they are interchangeably described as micro-, meso- and macro level (Geels, 2002b) through the vertical dimension.

LANDSCAPE/MACRO-LEVEL

The landscape-scale forms the external pressures on the regime, it is an agglomeration of slow developments that cannot be influenced or changed by just one single factor (Geels, 2002b & Raven et al., 2010). On a municipal scale influence is found through national regulatory policies, societal pressures, initiatives, and climate change (predictions). In this case, depending on the context they can function as barriers or drivers. (Geels and Schot, 2007). These pressures can open up windows of opportunity for different new changes (Geels and Schot, 2007).

REGIME / MESO-LEVEL

The central concept in the model is the regime. This term often gets negative connotation in literature about transition, as it is often used to explain why innovations do not break through (Raven et al., 2010). The regime in this study encompasses municipalities concerning their tasks and internal organization, due to their responsibility for the drainage of rainfall on public space. Within the socio-technical regime, a distinction can be made on actors and institutions/rules (Geels, 2004).

When looking further into the regime scale, horizontal connectivity is a term that can describe the interaction between those involved within the regime itself. (Brodnik et al., 2017). Less prominent in literature is the fact that current regimes evolved from previous regimes based on the same concepts to cope with problems from the past (Van der Vleuten and Raven, 2006). Which could have lead to an optimization of the regime with how to deal with problems of the past, but not necessarily with future scenarios.

For the urban watermanagement system, the urban socio-technical regime concerns a large stable network of the actors and institutions, which could cause a technological lock-in (Geels, 2002b; Geels and Schot, 2007; Van der Brugge, 2009 & Suleiman, 2021). These terms are respectively describing the lack of willingness and capacity to change the current framework and technologies that are sub-optimal but are maintained as the status quo (Pahl-Wostl, 2009). Geels (2004) states that even the existence and acknowledgement of problems in the current regime, could undermine the trust in current technologies. In addition, it could be that negative external effects are emitted from the regime to the landscape level or even within the regime thus requiring a change. To describe the regime more concretely, a distinction has to be made between different layers within a municipality. For which the top-layer concerned with policies and general management are the council and the board. Whereas, practitioner's level concerns the actors that usually are involved directly in decision making in projects (e.g. urban water engineers, maintenance units etc.).

NICHE LEVEL

The niche level describes innovations that are developed outside of or in cooperation with the socio-technical regime and have yet to be widely implemented within the regime. Often this term is used in a positive way as they bring new things to the world, in the MLP this is where radical innovations are developed and where they can grow and replace regime practices (Raven et al., 2010). Thus, they enable experiments that are part of the transition, so that actors can learn about them in a socio-technical manner. These niches in the case of this study are at present described as the SuDS that are sporadically implemented amongst different urban environments in pilot form, this process is useful for supporting their wide-scale adoption. Innovations may find their way into the regime initially when a municipality see's potential for in the long run offered by the niche (Geels and Schot, 2007). Other municipalities may learn from the experiences of early adopters, which may lead to a domino effect.

2.3. IMPLEMENTATION STRATEGIES: THE DEDICATED- AND MAINSTREAMING APPROACH

An important concept within the management of transitions is learning-by-doing and vice-versa, due to the path being unclear and thus experimentation is the way to learn (Van der Brugge and Rotmans, 2007). Geels and Schot (2007) states that different local-scale projects are not all focused on substituting existing technologies that form a regime. As Experimentation can also explore alternative technologies that complement the current regimes (Brown and Farrelly, 2008). From recent research, it is known that experimenting in niches is crucial for gathering knowledge about technical and social challenges for stimulation of transitions (Raven et al., 2010). Hegger et al. (2007) found that, elements such as technologies, institutions, cultural values , user practices, rules, and regulations are necessary to be upgraded in order to achieve more radical changes of complete socio-technical systems. Their research indicated that within existing niche management strategies, there is a large emphasis on technological experimentation, rather than the adaptation of the socio-technical regime.
Uittenbroek (2014) makes a distinction for the climate adaptation process between the dedicated- and the mainstreaming approach (See Table 2.2).

Table 2.2: Climate adaptation governance: dedicated vs mainstreaming approach (Uittenbroek, 2014).

A dedicated policy domain for adaptation	**Mainstreaming adaptation into other policy domains**
Climate proofing as the main objective	Climate proving as one of the objectives
Linear policy process	A dynamic policy process
Conformance to adaptation norms as criterion to assess policy outcomes	Performance as criterion to assess policy outcomes

Both transition strategies can promote a broader implementation of SuDS through kick-starting the adaptation curve for innovators and early adopters by conducting pilot experiments, in which the notion is that repetition of successful experiments may lead to further adoption (Brown and Farrelly, 2008). In practice, it is possible for these strategies to co-exist, or in time switch from a mainstreaming to a policy-dedicated approach.
The dedicated approach makes use of direct focus on climate adaptation through policies, where satisfaction is perceived as the implementation of measures that meet the criteria. This is associated with a shift in political agendas, resource allocation, and clear policy objectives (e.g. budgets outside of current domains, different governance, and even different departments) (Uittenbroek et al., 2013).
In literature, it is often found that governance of climate adaptation requires a new dedicated policy domain (Uittenbroek et al., 2013). However, empirical studies have shown that the preferred strategy in practice is not to create a new domain for climate change, but to transfer this to existing policy domains (Uittenbroek et al., 2013). This is supported by the preliminary interviews that were conducted within this study.

The mainstreaming strategy integrates climate adaptation into other policy domains to increase the opportunity for innovations and the effectiveness of policy making (Uittenbroek et al. (2013).

An addition is brought forward by Uittenbroek (2014) who states that mainstreaming can consequently increase practical adaptation initiatives that can increase the adaptive capacity of urban systems. This follows as current issues that span across different disciplines can be co-tackled at once (e.g. street renewal and permeable pavement).

The mainstreaming approach is based on in-direct political commitment. Meaning it relies more on the practitioner's level, where civil servants execute projects and function within their own policy domain. It is based on strategic ways to gain acceptance for adaptation and norms that have to be overthrown. These are necessary to establish policy synergies and mobilize actors and resources (Uittenbroek, 2014). When incorporating climate adaptation into existing policy domains, actors will have to consider the effects of climate change for their own domain, which in turn will lead to them having to make a decision (together) regarding the implementation of measures to reduce vulnerability (Uittenbroek et al., 2013). The approach is thus more pragmatic than the dedicated approach, as it is conserves the initial intentions of practitioners. This is expressed through performance being the criterion to assess policies and decision-making, rather than conformance to a checkbox of different rules.

2.4. THEORIES THAT RELATE ORGANIZATIONAL SIZE AND ADAPTIVE ABILITY

2.4.1. GOVERNANCE CAPACITY

Governance capacity is a term used by experts in the field which can be used to describe the quality of governance within a municipality or other organization, this term can be applied to measure to which extent municipalities are equipped to fulfill their tasks. A clear definition reads: "The ability of municipalities to fulfill their legal and autonomous tasks and therefore in social context to form the right connections" by Vries et al. (2019). This definition is also applicable to UWM in relation to SuDS. It is divided amongst the legal obligation in terms of taking care of the drainage of rainfall and groundwater, and the maintenance of the systems that do so.
Governance capacity can be divided into three pillars according to the theory proposed by Boogers et al. (2008). Namely, capacity related to: 1) execution, 2) decision, and 3) responsibility. The first term relates to how well the municipality can execute its tasks following legal procedures. The term relates mostly to how a municipality can critically weigh its decisions. Lastly, the responsibility aspect is related to the consequences of the legal obligations being executed following from National influence (landscape-level) and how they inform the stakeholders affected by those interventions (Boogers et al., 2008).

There are two approaches that describe governance capacity, of which the narrow concept states that when a municipality is larger in size the performance of its policies will grow. This logically follows from when more citizens are available, more resources become available enabling the hiring of workers at the policy execution level. This may be short-sighted as it mainly takes into consideration the first two pillars named by Boogers et al. (2008). A notion proposed in the report by Vries et al. (2019), in addition to the narrow definition, is that the importance of the local context and the role of managers within the governing body should be more emphasized. According to this principle, the construction of governance capacity is displayed in Figure 2.5. The municipality size does not solely determine the governance, however, the attributes which come in addition to the size of the organization (policy culture, motivation, resources, and others) do also influence the governance capacity. The figure shows that governance capacity has a few conditions which cause the respective capacities to be increased. The degree to how these conditions are met can indicate certain mainstreaming potential after operationalization of these different factors.

Furthermore, through the concept of governance capacity, a disparity can be identified between different Dutch municipalities. Within the Law of municipalities (Gemeentewet), no distinction is

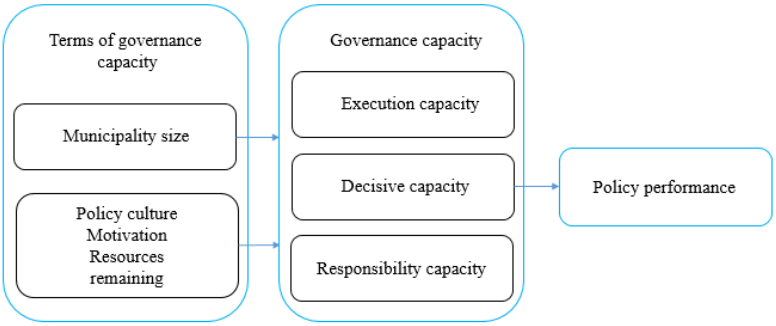

Figure 2.5: How governance capacity influences the mainstreaming performance (Adapted from Vries et al., 2019)

made between different sized municipalities. Thus, different municipalities are seen as equal and according to the law have to fulfill the same tasks. Throughout times, processes such as decentralization have taken place which in turn provided municipalities with more tasks. A notion brought forward by Vries et al. (2019) is that the governance capacity has not necessarily grown together with these new responsibilities, which makes it difficult for additional tasks to be accustomed for in smaller municipalities.

2.4.2. ORGANIZATION SIZE AND THE ABILITY TO CHANGE

Besides the concept of governance capacity, different scholars have attempted to establish a relationship between the size of organizations and their ability of incorporating change (e.g. Ford, 2009 & Haveman,1993). Both articles distinguish between two concepts related to organizational size:

- Rigidity of size: relates organization size to formalization, which promotes inertia and hinders adaptability.
- Fluidity of size: organizational size allows for more expertise and more internal mechanisms for enabling change. This concepts relates these factors to promotion of change.

Haveman (1993) found that larger organizations possessed more market power and available resources, which opened up opportunities for incorporating change. The market power and resources, were found to decrease importance of the sunk costs, economical barriers to entry and external political considerations. However, larger organizations were found to be more bureaucratic, and thus more prone to sustaining inertia. Positive relationships were recognized in multiple cases between size and adaptability. They found that within multiple of these positive relationships, mid-sized organizations within this industry seemed to encompass the best of both extremes (i.e. resource availability and flexibility). They acknowledge that a limitation of the study is that they attempted to establish a relationship between size and outcomes of change, rather than taking into consideration the contexts in the process.
Ford (2009) conducted similar research for establishing a relationship between organizational size and adaptive ability, except the context was taken into consideration in the process of incorporating change.
To assess the process of change, it was characterized into three phases Lewin (1947):

1. Unfreezing phase: Is the current regime working or can improvements be made? If so, changes can be planned

2. Movement phase: New behavior is planned and gives rise to changing the old patterns
3. Refreezing phase: The new behavior has to be internalized, and the organization has to stabilize around this new norm without relapsing into the old standard.

For the unfreezing and movement phases it is theorized that formalization with increased organizational size occurs and strengthens the current routines. These ingrained routines make switching towards novel approaches rather difficult. The different types of routines are elaborated in Appendix D3. In contrast, it is also named that formalization is a coping-mechanism for complexity. Thus, it may encourage specialization and innovation (Ford, 2009). Similarly, the routines are a method of scanning the regime in repetitive manner, where one may start to recognize possible improvements and how to incorporate them. Lastly, the structure for the unfreezing phase implies that likely only significant matters can enable changes within the regime. Hence, when a larger organization unfreezes, it may be a more well oriented process. The results of this study indicate that within the first two phases, no significant differences were observed.
However, in the refreezing phase it was found that larger organizations performed better at internalizing the new changes. Whereas, they found that smaller organizations start well but do not finish accordingly. The refreezing phase requires a confirmation of the effectiveness of the imposed changes on the goals of an organization, which is expressed in forms of feedback (e.g. measures, observations etc.) (Ford, 2009). This feedback can be utilized for ameliorating practises more towards the objective (organizational control). For smaller organisations these feedback mechanisms are largely based on social constructs (Ford, 2009). This is an advantage when concrete objectives are defined, however, in times of change this is usually not the case. Hence, even when implementation occurs, the lack of feedback and control may cause the refreezing process to stagnate earlier in smaller organizations.

2.5. KEYPOINTS LITERATURE REVIEW

- SuDS is the term that is used within this report to address innovations that are being tested at the Green Village in Delft.
- Adoption of innovations can be described by the adoption curve presented in Figure 2.2. For SuDS, the underlying framework of this adoption curve can be described by Figure 2.3. For this transition to happen, stakeholder receptivity of a municipality for prime implementation that serves for full scale testing.
- The MLP is a model that distinguishes how three levels interact (Landscape, urban socio-technical/socio-institutional, and niche). The focus is on the urban regime in this study, which concerns the environment of a particular municipality. Where the niche represents the innovations on the field-labs that are looking for their prime implementation.
- From the broad definition of governance capacity a link is made through the practitioner's level of municipalities and the execution of their tasks. Already a disparity is diagnosed between smaller and larger municipalities concerning their governance capacity, which hints to smaller municipalities being less capable of adaptation. The broad definition of governance capacity also includes the context in which the municipality operates (i.e. policy culture, motivation, resources etc.).
- The mainstreaming approach standardizes climate adaptation through integrating it along other policy domains and departments present in the municipality. In doing so, mainstreaming preserves the current structure of municipalities and knowledge distribution. Through the literature review and preliminary interviews it became evident that the municipalities considered, identify mostly with the mainstreaming strategy.
- Two theories are proposed concerning the size of organizations and their ability of incorporat-

ing change. These are the rigidity- and fluidity of organizational size. The differences again are highlighted to be found in the context, rather than the organizational size itself. According to Lewin's theory, the process of change can be divided into three phases: unfreezing, movement and, refreezing. Differences in organizational size and the ability to change are not necessarily found in the unfreezing phase, but rather in the refreezing phase. This was found in the fact larger organizations seem to be better at making structural changes. The reasoning for this finding was that the smaller organization lacked feedback and control mechanism to substantiate their changes.

3

THE ASSESSMENT OF MAINSTREAMING: A CONCEPTUAL FRAMEWORK

The theory presented in this chapter works towards, and supports, a framework that allows for an assessment of mainstreaming process of SuDS by dividing into different phases. These different phases are picked as a reconstruction of two different case studies which are conducted later in this document, this division may indicate when and where the certain factor is significant. The factors are also categorized so identification of its type is possible. To clarify the assembled framework, the different frameworks that describe the mainstreaming and implementation process are also elaborated. An elaboration of the main factors and their associated retrieved theories is given, for a complete elaboration of those factors please refer to Appendix **D**.

3.1. RECEPTIVITY ON PRACTITIONER'S LEVEL

Policy instruments in this document are deemed methods and tools to achieve certain policies. Whereas, the recipients are defined as those that have to execute the policies. To be more specific in the case of mainstreaming, this is the staff involved with the implementation of SuDS as consequence of the policies or policy instruments (climate adaptive related). It was found that the potential of the failure of instruments is related to the lack of understanding concerning the ability of recipients to incorporate the changes implied by an innovation into their current existing circumstances (Jeffrey and Seaton, 2004; Cettner et al., 2014; Koop et al., 2017 & Biesbroek et al., 2011). The understanding of this part of the socio-technical water system and its reactions to opportunities for implementation of SuDS should increase, in order for their response to and ambition regarding SuDS to change positively (Kiparsky et al., 2013). From the research by Uittenbroek (2016), it was found that mainstreaming climate adaptation into policies is different from mainstreaming climate change implementation processes. She found that well-formulated policies can stimulate practitioners to adhere, but it do not necessarily lead to more implementation (Uittenbroek, 2016). The reasoning for these findings were bound to the internal routines that had been established on practitioner's level, these are elaborated in Appendix **D**.
This can be linked to the concept of receptivity. Receptivity implies an ability or willingness to take in information or idea, in other words, the open-mindedness of people towards SuDS implementation. More case-specific receptivity in the context of this study implies that a new technology must

be designed from the end-user or recipient's point of view, thus from the perspective of the involved people and groups in the urban development projects at practitioner's level. The factors that encompass receptivity can be analyzed within a municipality, depending on how these are perceived they can function as barriers or drivers of implementation.

3.2. DIVIDING THE MAINSTREAMING FRAMEWORK INTO PHASES AND FACTORS

A plethora of research and literature is available on factors enabling or hindering the implementation of climate change adaption and (e.g. Brown and Farrelly, 2009 ; Biesbroek et al., 2011 & Cettner et al., 2014). Their content often tends to overlap due to different synonyms, case specific factors, contradictory factors, overlapping factors, and different governance scopes being used.
Furthermore, a large majority of these studies identify factors and even categorize them according to types (See appendix **A1**). Some articles do also assign those factors to different phases in the mainstreaming process, whether this is explicit or implicitly. Most of the frameworks do not distinguish between the dedicated approach and mainstreaming approach, but opt for climate adaptation in general. This is possible as explained earlier (See Chapter 2), from their definition it should be possible that they occur simultaneously or even in chronological order starting with mainstreaming.

3.2.1. DESCRIBING THE MAINSTREAMING PROCESS STEP BY STEP

From the retrieved literature different studies have taken an approach which consider that the mainstreaming approach can be divided into multiple phases. This notion resembles Lewin'stheory described under Chapter 2, which has a similar reasoning for adoption of change in organizations in general. Hence, these frameworks seem applicable for delineating differences retrieved through a comparison in different case studies. Uittenbroek et al. (2013), in particular has applied the framework proposed by Moser and Ekstrom (2010 for evaluation of the mainstreaming process dutch case studies in urban-planning. Other frameworks that were established apart from these aforementioned are the governance capacity framework by Koop et al. (2017) and the input-output model by Suleiman (2021). These follow a similar structure, for which their identified factors largely overlap with or complement the framework by Uittenbroek et al. (2013).

Three phases are outlined in the framework elaborated by Moser and Ekstrom (2010), which describe the mainstreaming process. In each phase different factors have been placed. The phases themselves consist of understanding, planning, and managing. They note that some of the barriers defined in an earlier phase may re-occur in later phases, hence the process is not linear but iterative. Uittenbroek et al. (2013) uses this framework as a base to conceptualize a framework that can evaluate mainstreaming of climate adaptation. Each of the phases consists out of sub-processes, which are displayed in the Table 3.1.

Table 3.1: Definition of the phases projected by Moser and Ekstrom (2010).

Understanding	**Planning**	**Managing**
Problem detection	Developing of options	Implement option
Gather and using information	Assessing options	Monitor option and environment
Define problem	Selecting options	Evaluate

As there are multiple departments involved when integrating climate adaptation amongst a municipality, their decisions should still guarantee performance in their initial domain rather than conform to a climate-adaptive norms. Hence, performance was described as the extent to which their initial objectives are reached and included in the final project as this affects future decision making. Which is why, in every phase a focus has been placed on the performance. According to this study, the factors related to mainstreaming climate adaptation can be categorized into the following types: social, cognitive, financial, technological, and organizational/institutional. These attributes were taken into consideration for the final framework.

3.2.2. THE RECEPTIVITY FRAMEWORK

The framework by Brown and Farrelly (2009) is based on the concept of receptivity, which stems from the 'innovation and technology transfer policy' studies by Jeffrey and Seaton (2004). This framework was used to assess the professional community's willingness and readiness to improve storm water quality management practices in their respective cities. They state that there are four attributes that policymakers and strategists should realize from the recipient's perspective, which are put into a perspective of different phases by the framework of (Brown and Farrelly, 2008), see table 3.2- for the four-factors and their brief explanation.

Table 3.2: The Four-A factors by Brown and Farrelly (2009).

Awareness	An organisation or individual recognizes there is a problem
Association	Individual or organization relates to the problem
Acquisition	Individual or organization has enough skills, capacity and support for implementation
Application	There is enough stimulation for implementing solutions

This framework has been applied in multiple cases, for example by: Cettner et al. (2014) and Veldkamp (2020). According to Cettner et al. (2014) it explicitly lacks the factor of context, but from the research mentioned above, it seems that this framework takes context into consideration implicitly. Cettner et al. (2014) argue that this can be countered by elaborating on these factors and integrated an expansion of this framework using the Eight-factor approach by Pettigrew et al.(1992) (See Appendix **B**). The context is best described as the environment in which decisions are made, this can include factors such as political support, financial support, and commitment, which allow for coherent (unwritten) rules that make sure different actors and networks are highly anticipated on each other (Suleiman, 2021). Together the frameworks assess the openness of individuals and organizations and they consider the context in which decisions are made. When comparing this model to the phases framework, this framework clearly focuses on the understanding and planning phase, however leaves out the last phase which is focused on evaluation after implementation.

The third framework considered is the governance capacity framework (GCF) by Koop et al. (2017), one of its utilities is for comparison of different cities in their governance capacity. It addresses multiple challenges including (Waste) water and climate change (only applied for Urban heat island), which supports the importance of governance factors that hinder the implementation of adaptive measures. They state that the governance challenges include many causes that lead to uncertainty and disagreement, and found that there is usually not one single best approach to solve them. Hence, they argue that what is needed is an iterative process, which in turn requires finding long-term solutions through using interim targets. As a result of these interim targets, evaluation can take place, which in turn can lead to improvement of the incorporated changes (Koop et al., 2017). This is a key difference between the receptivity model and the GCF, as interim targets after an iteration of implementation in the form of evaluation are not explicitly presented. These check-up

points may for example be interesting to see why an innovation didn't achieve further implementation than the full-scaled pilot. They came up with three dimensions/phases: knowing, wanting, and enabling. Their phases largely overlap with the receptivity framework, but are formed based on an independent approach. In their framework they have also incorporated the meaning of contextual influence on decision-making, which they state is lacking in other research (e.g. Brown and Farrelly (2009). Similar to the phases model, an iterative approach is implied thus creating a repetitive loop for a certain innovation, which means that the more this loop is executed, the higher an innovation will place in the adoption curve.

Suleiman (2021), explored the transition from niche to mainstream of SuDS in three different cases in Stockholm. She proposes a methodological framework that divides the barriers into: receptive context, actors, instruments, processes outputs and outcomes, and impacts. According to Suleiman (2021), the regimes may be stable, but not closed for influence from landscape or niche level. This is due to the context continuously changing, hence on a temporal scale, different pressures are inflicted on the regime which creates new possibilities for technological innovation paired with social structure change. The receptive context indicated here, overlaps with the factors described by Brown and Farrelly (2009) and Cettner et al. (2014), which are based on awareness, resources, coherent and supporting regulations, coordination of responses by aligned actors, and human agency.

3.3. THE COMBINED CONCEPTUAL FRAMEWORK

All the frameworks considered, do basically describe the same process towards mainstreaming of SuDS, with differences in terminology. They all start with the receptive context in which awareness for a problem takes place and the organization can relate to it. Once organizations or individuals understand the problem and its possible solutions, they will have to associate through weighing the consequences of such a solution. These first two phases form the initial conditions, after which interaction has to take place. This interaction has to occur at the practitioner's level, for which actors need to posses the skills and drive for this adaptation. Implementation could finally take place after successful completion.

3.3.1. NOTIONS TAKEN INTO CONSIDERATION

A combination is made of the frameworks mentioned above, using the framework of (Uittenbroek et al. (2013) as a starting point. The division of the mainstreaming process in different phases makes the evaluation of case studies using reconstruction more clear. Other factors found by scholars (See Appendix **B**) and the three frameworks elaborated above were used to elaborate the phases. For the assembling of the framework, the following matters were taken into consideration:

- The framework by (Uittenbroek et al. (2013) mentions that performance is central in decision making, which is not found in the other frameworks. This is based on the outcomes of each phase, which also take into consideration that simultaneously the (core) ambitions and wishes of different departments should be taken into consideration.

- The framework by (Uittenbroek et al. (2013) is based on the framework presented by Moser and Ekstrom (2010) (See appendix **C**), fundamentally they are the same. When using this framework one should take into account that this is an idealized portrayal of a rational approach to a decision-making procedure. Barriers hinder progress from one phase to another, these issues that arise may be disregarded in practice sometimes. In a similar way phases can

be skipped, both types or shortcuts result in problems or unintentional consequences later (Moser and Ekstrom, 2010). Another notion using this approach is that certain (types of) barriers may re-occur in different phases or not, this is case dependent and part of the iterative process for describing the mainstreaming process as mentioned by Koop et al. (2017).

- The framework lacks pre-information formed by drivers from the landscape or local level, these drivers are not necessarily part of the mainstreaming process in literature. But, they do offer better insights into the full decision making process. Demo-testing in form of experiments can be implemented by the municipality itself, but also by other parties where field-lab testing takes place (de Graaf-van Dinther et al., 2021. They are elaborated in the chapter of transition theory, at the beginning of an adaptation cycle. In demo-testing, the performance and reliability of innovations are evaluated, after it is proven successful full-scale testing can take place (See section 2.2.1). This full-scale testing is the first iteration of the mainstreaming process and prime implementation of a novel SuDS. When other municipalities take inspiration of this first implementation by knowledge sharing, one could interpret the first full-scale implementation as demo-project for this new iteration.

- The framework takes into consideration a broad range of factors, and indicates that the same (types of) barriers can be present in different phases (see Table 1.3). Theoretically, one has to classify certain factors within specific phases, Koop et al. (2017)'s was used as base for the initiation phase.

- The former three frameworks mentioned seem to work in the most chronological order, before you can act you first have to be aware and understanding of the problem and the considered options. Different terminologies overlap with the understanding phase, which are awareness and association (Brown and Farrelly, 2009); or knowing and willing (Koop et al., 2017).

- This framework then proceeds to head into the planning phase, where the framework by Koop et al. (2017) seems to have two phases in between namely: wanting and enabling. The wanting dimension boils down to engaging stakeholders and having ambitious management and the enabling capacity comes down to skills. This is supported by Brown and Farrelly (2009, which consider acquisition and application.

3.3.2. THE CONCEPTUAL FRAMEWORK FOR MAINSTREAMING

In Figure 3.1, the conceptual framework for mainstreaming evaluation , to utilize this for the objective different factors were retrieved for each phase. It concerns barriers and opportunities that can alter the performance of the mainstreaming process. The first time the mainstreaming cycle is conducted within a municipality, depending on where its position in the adoption curve (Figure 2.2) it is deemed a full-scaled pilot project. The mainstreaming cycle describes iterations of implementation processes, which when repeated form the mainstreaming. Five phases were projected in the mainstreaming process, of which the initiation phase consists of three different elements. The regime within the mainstreaming process is scoped by the practitioner's level as described under Section 2.2. Again, as research mentions that transition within the regime can't happen without human involvement and representation, pressures do not affect the regime itself, but the human actors which need to translate the theory to practice (Suleiman, 2021).

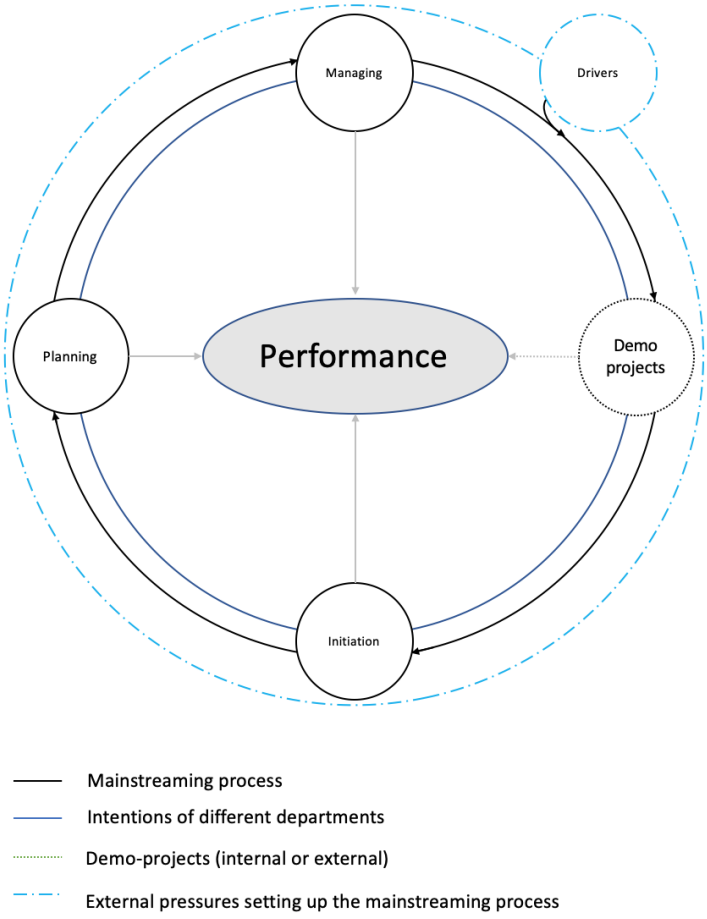

Figure 3.1: Conceptual framework for mainstreaming adapted from (Uittenbroek et al., 2013)

In Table 1.3 a comprehensive overview of the factors per phase is presented. The assigning of factors to a specific phase is difficult to execute in an exact manner and so is the division of phases, as this is case-dependent. In the following sub-sections, the main factors per phase are described. For a more extensive elaboration on the factors please refer to appendix **D**

Table 3.3: overview of factors influencing the mainstreaming process per phase. Urban watermanagement has been shortened to UWM

Phases	Drivers	Understand	Willing	Enabeling	Planning	Managing
A A A A A A A A A A AA A A A A AA A A A AA A A						
A a a a a A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A						

THE DRIVERS AND EXTERNAL PRESSURE

The process starts with drivers which are part of the external pressures that are exercised on the regime. These are factors that form a sense or urgency. These can be formed by political attention or even obligations on local or national level. Furthermore, urgency can be established by sewer deterioration, extreme event occurrence or transition scenarios (Zimmerman et al., 2008; Uittenbroek, 2016 & Cettner et al., 2014). In Figure 3.1, the external pressure is depicted with drivers linking the external and regime level. However, even in later phases throughout the the cycle it is possible that external pressures still have an influence on the mainstreaming process (e.g. later policy establishment).

DEMO-PROJECTS

Demo-projects usually take place before one implements a full-scale testing project within a municipality (de Graaf-van Dinther et al., 2021). These experimental projects are usually temporary and serve the purpose to explore if they are eligible for up-scaling (See Figure 2.3). These have been placed within the regime, but could also take place at external facilities. Where they are placed is a matter of subjectivity, one could state that they are drivers if they happen on an external field lab where knowledge is gained on their performance. However, the interpretation of this information could belong within the initiation phase. In the following phases, the focus shifts towards the practitioner's level where barriers and opportunities are present of cognitive, social, technical and organizational types of factors are present.

THE INITIATION PHASE

The initiation phase is subdivided into different components as mentioned earlier namely: understanding willingness and enabling. As different actors within municipalities are involved in the issue of climate adaptation, their different backgrounds provide them with different knowledge. Examples of actors cited from Suleiman (2021) are: sewer-managers (maintenance), geohydrologists, landscape architects, street traffic planners, environmental planners, and (water) engineers.

To form an understanding; knowledge, and information concerning SuDS are required, these have to be distributed within the municipality through communication. Theoretically, these are different phases. However, from a practical point of view, these phases are hard to distinguish. Different factors associated include the availability of information, accessibility of information, uniform interpretation, and activation due to information (Brodnik et al., 2017). Actors within municipalities could have fragmented knowledge, which implies a lack of coordination between institutions, organizations, individuals, and policies at different levels or within the same level (Biesbroek et al., 2011).
The knowledge that is available, should be spread which can be elevated through horizontal and vertical connectivity within the organization (Biesbroek et al., 2011). This can be achieved through **boundary-spanning**, which is a theory concept that stems from the notion that policy formation should be replaced by experience which results from practice (Slob and Duijn, 2014).
Boundary spanning can support the understanding of how to deal with different perspectives of actors considering an issue, according to Slob and Duijn (2014) the verb implies taking action to convey communication and knowledge between separate communities, which is done through crossing so-called "boundaries". Similarly, Tushman (1977), states that boundary spanning is the action of individuals who adopt the role of linking an organization with external knowledge. In addition to these definitions is not only the brokerage of knowledge, but the mobilization of action (Bechky, 2003 & Slob and Duijn, 2014).

Boundary spanning activities happen through so called "boundary spanners" or as mentioned in other literature "agents of change". These people need to have the intrinsic motivation, willingness to take risks to push SuDS through the inertial systems. Besides that their part, support needs to be found within the municipality to an extent. These people are not limited leading positions, but involves all actors that part take into the practices concerning the current inertia (Koop et al., 2017). Koop et al. (2017) lists three different types of agents which fulfill these attributes: entrepreneurial agents, collaborative agents and visionary agents. The entrepreneurial agents have the means and skills to gain access to resources, seek opportunities and manage risks, they are also described as the key people that are leading change (Cettner et al., 2014). The collaborative agents enable the formation of cooperation between different actors. Visionary agents envision long-term adaptive approaches and are able to steer current policies and actions into that direction.
Besides the differences in knowledge between the departments, the element of willingness introduces boundaries which are present in norms and goals. Hence, the step after understanding, is the presence willingness of willingness by actors for implementation (de Graaf-van Dinther et al., 2021). Similarly, the management and actors that should be supportive of the implementation. Again, if this is not present boundary spanning activities may be highly important for changing attitudes of those involved. An additional factor which may be of high relevance in this element is the presence of self-reinforcing mechanisms (Uittenbroek, 2014), these have been elaborated under Appendix **D3**.

3.4. THE PLANNING & MANAGING PHASE

The planning phase is divided into three sub-phases: developing options, assessment of options, and selecting options. When an option is selected it can be implemented, monitored, and evaluated which together form the managing phase. The monitoring and evaluation of an implemented innovation are essential for the mainstreaming approach since they support institutional and social learning, which can offer insights into complex and uncertain problems in the future (Moser and Ekstrom, 2010). One can than reflect on the question if the transition experiment can be transferred to different contexts. Following from this notion follows information concerning the questions: "how and if the experiment has potential for scaling up". Where the importance of communicating this towards other parties of interest, whether it being internal or external, facilitates this up-scaling process (de Graaf-van Dinther et al., 2021).

3.5. KEYPOINTS FRAMEWORK SECTION

- Drivers do not influence the regime in general, but it's practitioner's level. It was found from research that the actors that operate on practitioner's level are the key links for mainstreaming performance.
- The mainstreaming process can be divided into an interative process with different phases, namely: drivers, initiation, planning, and managing. The drivers are mostly based on available policies, budgets and a sense of urgency. Every time that a loop is completed, an innovation places higher in the adoption curve and gains more credibility. Initiation is described by three elements which concern information, willingness and the enabling, these have to be present simultaneously and are hard to distinguish in practice in chronological order.
  - Boundary-spanners and key-agents of change are valuable actors that can promote the awareness of solutions and problems within an organisation. In turn these may lead to adaptation and willingness formation.
  - For willingness formation on practitioner's level both managers and workers are required to be ambitious concerning the change. Rigidity in this phase seems to be caused my self re-in forcing mechanisms.
- Once an innovation is implemented, it has to be maintained properly, and its performance has to be monitored. Only than can an evaluation take place whether it is a solution that has up-scaling potential. And if that's the case, this knowledge has to be spread for up-scaling to actively happen/

4

METHODOLOGY

In this chapter, the methodology and research design are elaborated, which consist of the chosen methods and how they are executed. Two case studies are proposed, one concerning the 'urban water buffer (UWB)' which was executed under the assignment of the municipality of Rotterdam, and a second one concerning the 'Buffer Block ' at the municipality of Capelle aan den IJssel.

A brief overview of the research characteristics is provided in Table 4.1. In section 4.1, the research type is elaborated. This is followed by an elaboration of what the literature study and conceptual framework will be used for. The research procedure that will follow the work presented in the previous steps will be elaborated in section 4.2. This is supplemented by the data sources and collection & data processing (sections 4.3 & 4.4). Finally, the validity of the research is explained under the final section (4.6).

Table 4.1: Description of research characteristics

Research type	**Qualitative research - descriptive and explanatory**
Strategy and purpose	Observe – Research gap Literature review – Theoretical background and framework Case studies – Data gathering & processing Synthesis – Comparison outcomes
Methodology	Case studies
Choice of case studies & data	Purposive
Data collection	Documentation Semi-structured interviews
Data processing	Atlas TI or manual processing interviews

4.1. RESEARCH TYPE: QUALITATIVE CASE STUDIES

The methodology is qualitative of nature in the form of case studies. Rather than finding out how many barriers are able to be retrieved, finding out which ones do appear and how they appear was chosen as a more pragmatic approach to reaching viable results. This is a fundamentally different goal, as these are about understanding the experiences of those involved at the practitioner's level. In a simplified manner, qualitative research opposed to quantitative research focuses on words as data rather than numbers, where respectively they are analyzed in other ways and by statistical analysis (Braun and Clarke, 2013 & Merriam and Tisdell, 2015). The first intention of this research is rather exploratory, which is related to probing if differences can be found related to the different sized municipalities. Since differences were found between different sized organizations, the intention has shifted towards explanatory research. This implies finding a description, understanding, and interpretation of the findings related to the research objective.

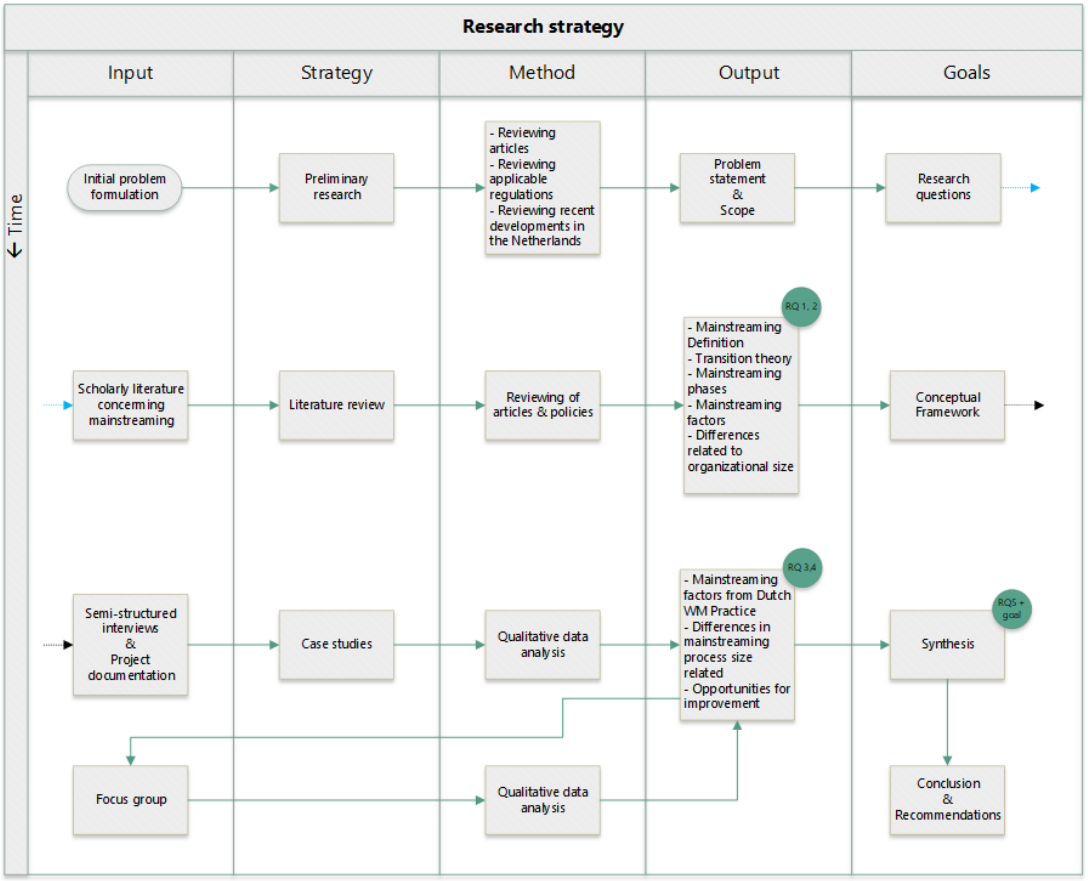

Figure 4.1: Description of the procedure that has been followed for this research (RQ stands for research question(s))

4.2. RESEARCH PROCEDURE

The initial research procedure concerns the work that has been presented till now. First, an initial problem formulation was proposed which was quite similar to the current one, however, it turned out to be more explored territory than anticipated. This was taken as the starting point (See Figure 4.1). The initial research was expanded through introductory meetings with the graduation committee, further literature research, interviews with municipalities of Rotterdam and Katwijk and also taking into consideration different documents provided by initiatives proposed under section 1.2. The final product of this process wer the problem statement and scope. Following the problem-statement were the research questions.

As the first step, a literature review was performed in combination with a mapping of the applicable policies. Outputs of this phase were transition theory required to see how the adoption process of an innovation develops through time. The importance of the context was highlighted through the introduction of studies that had attempted to establish relationships between organizational size and the adoption of change. They also highlighted the notion of context, which is where mainstreaming in the regime takes place. Following this elaboration, the mainstreaming process had to be described, while organizing the factors in a systematic manner. This answered the first two research questions which were mostly based on literature review, however, the factors retrieved were only applicable to municipalities in the Netherlands in general. Nor, were the retrieved organizational size differences applicable to municipalities in the Netherlands. Hence, for answering research questions three and four, case studies were executed.

To gather information on the mainstreaming factors in practice, case studies in two different sized municipalities were conducted. The results of the case studies were than compared, to highlight the similarities and differences in both types of organizations. Additionally, the most important criteria can come forward from such an analysis for both sizes of municipalities.

For the selection of the case study different criteria were assembled:

- Similar technical boundary conditions/water issues (high groundwater level, weak soil) in the municipalities
- An innovation that completed the first iteration of the mainstreaming cycle recently, for the reason that the knowledge is still recent. And from practical experience, it is possible that people that worked on projects are now working at different companies.
- This innovation should be related to technology presented at the Waterstraat at VPdelta (i.e. water buffering, water infiltration, and even water treatment, as this offers the benefits of the potential network that is available.

The case studies were eventually in a rather opportunistic and purposive manner, while still keeping in mind the above requirements. For the larger case study, the municipality of Rotterdam was chosen where the UWB and the case study in the smaller municipality was Capelle aan den IJssel where the Bufferblock was implemented (See Table 4.2).

Table 4.2: Brief description of the case studies

	Case study: Urban Waterbuffer Sparta	**Case study: Bufferblock Capelle A/D IJssel**
Municipality	Rotterdam	Capelle A/D IJssel
Size of area	~324.1 km2	~9.47 km2
Inhabitants	~650,000	~66.818
Type of project	Multi-functional waterbuffer that makes use of the deep undergroud(storage, treatment and re-use)	A solution for stormwater drainage and buffering. The solution incorporates hollow concrete blocks.
Process actors	Plan by: Municipality and Fieldfactors Consulted by: KWR, Evides	Plan by: Municipality and Bufferblock B.V. Consulted by: Tauw B.V.
Duration project	2016 – 2018	2018 – 2020

The case studies served as a purpose to find where in the mainstreaming process which factors are present in which phase in practice, in such a way an overview could be created. The case studies were executed by performing semi-structured interviews and obtaining project documentation, which were both analyzed. Information concerning mainstreaming factors in Dutch urban water management practice followed. As well as opportunities for improvement. Finally, a focus group was organized, with an objective to evaluate how the results relate to experiences from other municipalities. Similarly, differences in the mainstreaming process related to the size of municipalities could be drafted, through a discussion. Within the discussion the previous findings of the literature studies were incorporate aswell. The conclusion and recommendation for further research and improvement of mainstreaming were finally reported.

4.3. DATA SOURCES AND COLLECTION

Data was primarily based on primary knowledge that was gained through those that were directly involved in the implementation process. The primary data was meant for reconstructing the phases presented in the framework, where mainstreaming factors were identified from and clarified what hat happened in the process. The data collection was done in a purposive manner, hence the data that was used to substantiate the studies, was already sampled towards the objective. The primary data consisted of results from semi-structured interviews. The 'semi-structured dialogue' approach is described by Whiting (2008). The advantage of this interview style is that it allows for keeping an open and natural conversation flowing where participants can fully express themselves without interference of the interviewer. To keep the interview semi-structured, questions were noted upfront based on the conceptual framework. Additionally, the participant is allowed to disclose any information he or she feels like sharing that can contribute towards strengthening the case study. The documentation that was inquired generally per phase is best distributed in the classes depicted in Figure 4.2.

Figure 4.2: Overview of required documentation per phase

A list of the interviewees that have participated in both the preliminary study and the case studies is provided in table 4.3. These interviewees naturally followed after speaking to the project leaders involved in both cases.

Table 4.3: List of participants in interviews

Interviewee #	Organisation	Role
Initial interviews		
Interviewee 1	Municipality of Rotterdam	Stadsontwikkeling - Senior role
Interviewee 2	Municipality of Rotterdam	Stadsontwikkeling - Junior role
Interviewee 3	Municipality of Rotterdam	Stadsontwikkeling - Junior role
Interviewee 4	Municipality of Katwijk	Water strategist - Senior role
Case study interviews		
Interviewee 5	KWR	Projectmanager role
Interviewee 6	Municipality of Rotterdam	Stadsontwikkeling senior role Project Role: Consultant
Interviewee 7	Field Factors	Founder startup
Interviewee 8	Municipality of Rotterdam	Stadsontwikkeling senior role Project role: Initiator and Consultant
Interviewee 9	Municipality of Capelle a.d. IJssel	Stadsbeheer BOR - senior role Project Role: Projectmanager
Interviewee 10	Municipality of Capelle a.d. IJssel	Stadsbeheer / I.B. - senior role Project Role: projectmanager
Interviewee 11	Bufferblock B.V.	Founder startup
Interviewee 12	I.B. Tauw	Consultancy role
Interviewee 13	Evides	Strategist

4.3.1. URBAN WATERBUFFER SPARTA – LARGER MUNICIPALITY

After having contact with the initial interviewee from the municipality of Rotterdam, the Urban Waterbuffer which was implemented at the Sparta Stadium in Rotterdam was proposed based on the criteria in section 4.2. Within this process, it was learned that there is a second stage of urban water innovations going on. These new types of SuDS are trying to incorporate for circular water use. Contact with the key people involved in this project was soon set up through the contact of the initial interview with Rotterdam. and different kinds of documentation were provided through a snowball

effect. These documents were distinguished into:

- Documentation concerning the municipal plans
- Structures of the meetings and (some minutes)
- Documentation of project plan versions
- Documentation concerning the budget
- Documentation concerning the performance after implementation

Supplemental to the documents, documents of involved initiatives, national- and regional policies relating directly to the case studies study were taken into consideration too to identify potential drivers. From documentation only, factors didn't become evident right away. The documentation couldn't describe what happened on practitioner's level enough, which is where interviews were of high importance for this phase. These interviews were also of great benefits for gaining insights in the other phases.

4.3.2. BUFFERBLOCK CAPELLE – MID-SIZED MUNICIPALITY

Contact was initiated through the network of VPdelta with different municipalities. Due to the requirements of section 4.1, it was rather difficult to find a mid-sized municipality that had the capacities and options to support the research. Eventually, through the network of VPdelta and other students, the case study in Capelle was found. This case study covers the implementation of the Bufferblock in the municipality of Capelle, which is an innovation that was present at the Greenvillage at the time.

- Documentation concerning municipal plans
- Project plan document
- Document concerning the initial ideas
- MCA of different alternatives
- Grant application
- Document with stakeholders
- Progression Report

From the start of this contact, it became evident through verbal interaction who were the key people within this case study that could be interesting for interviews. Similar to the case study of Rotterdam, other active policies at the time of implementation were considered, but Capelle did not yet have a concrete history of climate adaptation nor any active policies in place.

4.4. PROCESSING OF CASE STUDY DATA

In the data processing phase, the given data has to be organized which can be done according to the conceptual framework. The reporting of the factors will be done under chapters and sections representing respectively the phases and sub-phases.
To set up for the reporting, different documents are analyzed manually. The interviews themselves will be recorded so that they can be analyzed afterwards. Through the application of Atlas TI, the interviews are transcribed, coded, and grouped. After this is done, they can be placed within the framework again to allow for comparison between the two cases. In a similar way, this is done for the focus group.

4.5. FOCUS GROUP

A focus group is a group discussion that is focused on a specific topic and guided by a researcher. For practical purposes, the focus group that is implied in this thesis will be held online. Gilbert and

Stoneman (2015) states that "the main goal of a focus group is to gain insight and understanding by hearing from representatives from a target population".Applying this notion to this thesis, the main goal is to assess the findings from the case studies, through discussing them with other municipalities of similar sizes as in the case studies. To be more specific within those municipalities, people that had knowledge of the implementation processes within their own municipality were required. This type of purposive sampling placed constraints on the municipalities and people that were eligible.

The reasoning for the focus group size has been attempted to be described from a theoretical point of view, in general, they consist of 4 - 12 people (2011, Carlsen and Glenton). They do also state that the overall reporting on sample size and explanations are poor. When explanations were given "data saturation" which was interchangeably used with "purposive sampling" (Carlsen and Glenton, 2011), which do not really offer an answer to the reason for picking certain sample sizes.

Instead of basing this on theory, a sample size of four people was chosen based on the logical sense as follows:

- The group discussion was hosted online, as it is harder to manage a larger group given the circumstances.
- Using a smaller group made sure that everyone can deliver their input, plus it inhibits the phenomenon of an echo chamber.
- A smaller group size allowed to discuss answers more deep, which adds more substance
- As most of the participants are workers at the municipality, their schedules are tight hence the duration of the session is limited. In addition, as their schedules are tight it is hard to find people that are willing to take the extra time of the day.

Similarly to the case studies, the participants were chosen through the network of VPdelta. The participants are divided amongst two workers from mid-sized municipalities and two from larger municipalities. Within the focus group, different statements are proposed to probe what the different views of the participating municipalities are. The data collection and analysis will take place in a similar manner to the interviews, respectively through the recording and the principles of Atlas-Ti. The participants have been listed in Table 4.4 (It was discussed that they would be incorporated anonymously).

Table 4.4: Focus group characteristics of participants

Participant	Municipality Size	Role
P	Mid-sized	Senior projectmanager urban watermanagement
R	Mid-sized	Policy officer climate & water
S	Large	Policy advisor climate adaptation
A	Large	Senior projectmanager / consultant urban watermanagement

4.6. VALIDITY OF RESEARCH

Bryman (2008) states that most of the respondents to their sample found that for qualitative research the most important one seemed to be validity. The author distinguishes between internal and external validity. Internal validity was described

Internal validity relates to the choice of methodology, and external validity more to the generalizability of the results.

The methodology incorporates a triangulation of the data, which is mentioned as the best-known strategy to create a higher internal validation. Denzin (1978) distinguishes four types of ways to triangulate data and confirm findings:

- Use of multiple methods
- Multiple sources of data
- Multiple investigators
- Multiple theories

The main method that has been applied in this thesis is the use of multiple methods and data. A literature review has been conducted for which the state-of-art literature concerning factors has been introduced. This has been followed up by case studies and focus groups which are two different methods. For which the focus group is meant for establishing how well these results apply to other municipalities. These three methods are associated with different types of data: literature, interviews and documents, and a group discussion.
Another important aspect is the interpretation of data. This all depends on the main tool which in qualitative research is the researcher him- or herself. For which ultimately the choices and thought patterns would be difficult to replicate without an accurate description of my choices. A description of the choices has been provided in terms of documenting the literature review, case studies (semi-structured interview template) and focus group.
Furthermore, within the case study cross-checks of data with documentation and interview participants were conducted.
This research is based upon different case studies, of which two were chosen in different sized municipalities. Case studies are types of qualitative research, in which data is gathered about something, with the purpose of learning about an unknown or poorly understood situation (Leedy and Ormrod, 2005). They are supposed to represent a larger group than the case itself, even though the generalization could be in a tentative manner (Gerring, 2008). The choice of case studies allows for a comparison between a G4 and an average medium-sized city, but it is limited in forming a general conclusion for municipalities (of other sizes). The purpose of this research is explanatory, and it can therefore offer an indication towards generalization.
The case study selection can also be seen as rather challenging. The selection for the case studies was purposive just like the data gathered, which made sure that a representative sample was chosen. In a purposive manner, the distinction between two sizes of municipalities had to be made which allows for covering for a large variability. From another standpoint, the two of them were chosen due to practical considerations. The contacts were in the network of VPdelta and it is well known that Rotterdam is pioneering in the field of SuDS. The other municipality had to be of medium size, for which Capelle was selected. In both municipalities multiple participants were interviewed, to the generalization of the case as more people are involved. Early on it was found that cooperation of smaller municipalities was relatively harder, due to not having any case studies available that fit the criteria or hesitation concerning the study and possible effects on their internal cooperation.

Another notion for the selection of the cases is described by the cross-case attributes of a case study. The attributes describe how a case study fits into the larger population it should represent (Gerring, 2008). One of the methods that are proposed is the diverse cast, which is most applicable towards the choice of methodology in this study. The concrete definition by Gerring (2008) reads: “Two or more cases exemplify diverse values of X, Y or X/Y”. This diversity is described in this case by using categorical values (i.e. factors identified within the of two samples).

When executing a similar method, whether it is being qualitative or quantitative research, the results may vary as replication of the exact same conditions highly unlikely. The literature review takes into consideration many different articles for establishing the factors. For the importance of the factors, four different articles were available. Of which two were applicable to the Netherlands. The methods and tools that have been presented in this chapter, should offer a good base for replication of this experiment.
Factors that have influenced the external validation, are the choices that were made concerning the literature review, framework, and the execution of the case studies. To be more specific the choice of municipalities, where case studies and their boundary conditions could vary, the chosen stakeholders within those municipalities, the obtained documentation and interview output. To support the case study findings, the focus group should offer an indication of what is relevant in other municipalities too.

5

CASE STUDY: THE URBAN WATERBUFFER IN ROTTERDAM

In this chapter, the results of the case study of the Urban Waterbuffer (UWB) in the municipality of Rotterdam are elaborated. The conceptual mainstreaming framework has been applied. The third research question is answered which concerns the drivers and barriers that are found in practice.

In section 5.1 a brief introduction is given to the case study. Section 5.2 contains an analysis of the most important stakeholders. Section 5.3 describes the decision-making process per municipality, and section 5.4 describes the case studies according to the framework. Thus dividing the mainstreaming process per case study into different phases, here drivers and barriers are identified In this last section, the barriers are identified based on the documentation and semi-structured interviews that were taken into account. In this section many references are made to the interviewees, for the roles of the interviewees please refer to table 4.3. The key factors have been reported in table form in section 5.5.

5.1. INTRODUCTION OF THE CASE STUDY

The UWB is located in the neighborhood of Spangen in Rotterdam (See Figure 5.1), a neighborhood located north of the harbor district.

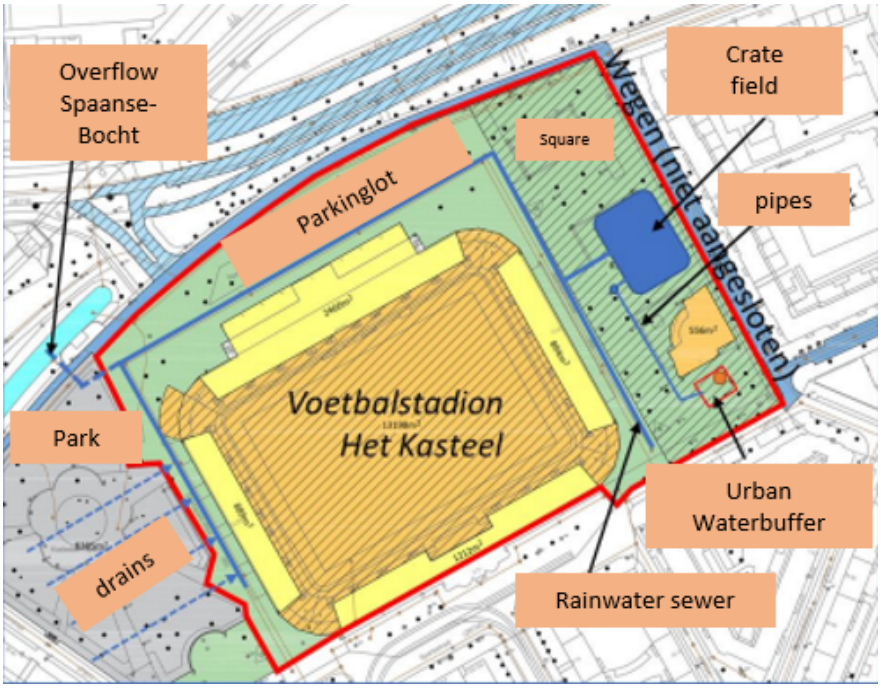

Figure 5.1: Overview of drained areas around the Sparta Stadium by KWR (2019).

Sparta's soccer stadium, Het Kasteel, characterizes the neighbourhood being the oldest soccer stadium in the Netherlands. The UWB located in Rotterdam at the Sparta Stadium is part of a larger project by TKI Water technology. This is a project group of cooperating parties which are interested in the experimentation with deep aquifer storage. Three different projects using this application were scheduled in the province of South Holland: Rotterdam, The Hague, and Rheden. The first time this technology was implemented in an urban environment was in Spangen. The goal was to find out if these UWBs could aid in the prevention of pluvial flooding and improve the water cycle (KWR et al., 2016).

The UWB stores rainwater which falls on the Sparta Stadium and the areas connected to the rainwater sewer (See Figure 5.1). First, the water is collected under a Cruyff-Court (Small soccer field), in a Crate-Field. This is a type of buffer directly under the surface, which is used for immediate storage of the rainfall. In the past, the surplus of water would spill on the Spaanse Bocht, which could not provide sufficient drainage and storage capacity.
The Crate-Field is of utmost importance as the helophyte filter and infiltration system into the aquifer do not have enough capacity to accommodate for higher rainfall intensities. The water is then pretreated as it flows through a vertical helophyte filter (Bluebloqs technology).

This type of treatment is based on the principle of sand filtration, and mainly removes the larger particles and light fluids. The water is then moved towards an infiltration well, where it infiltrates into the deeper sand layers, and is subsequently stored in the freshwater aquifer. This water is later recovered through extraction for irrigation of the fields of Sparta, irrigation of the Bluebloqs, and towards a water pillar in the neighborhood. The UWB decentralizes approximately an area of 45.000 m^2 and is designed for saving 10.000 m^3 of drinking water on an annual basis. A schematic overview is presented in Figure 5.2. For a more specific technical elaboration please refer to KWR (2019).

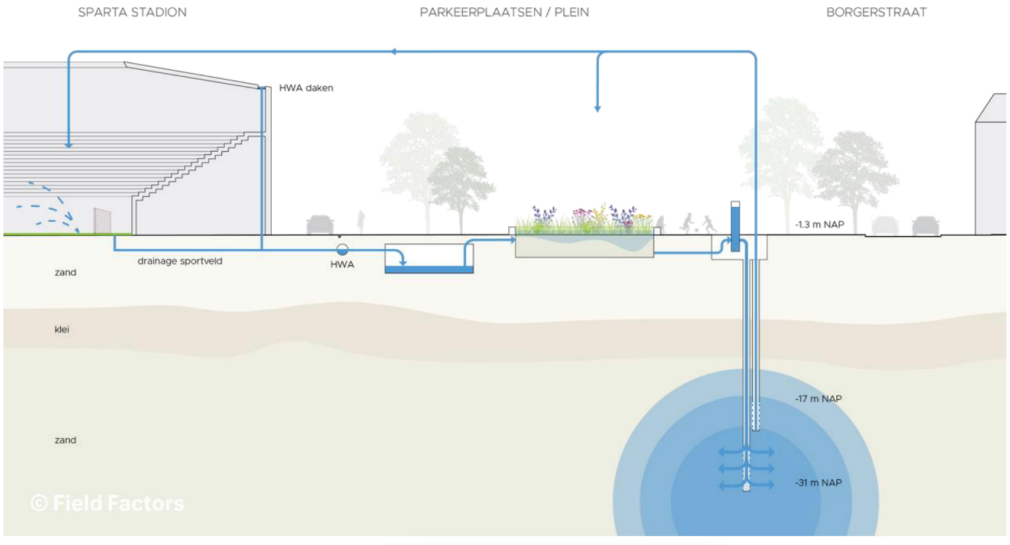

Figure 5.2: Overview of the UWB system (KWR, 2019).

5.2. STAKEHOLDER ANALYSIS

As preceding step to the interviews, the relevant stakeholders per case study were identified through a stakeholders analysis. The stakeholder analysis in this section is different as opposed to a regular stakeholder analysis, as the objective is to find the key people involved in the mainstreaming process. Its primary focus is the identification of the parties that were directly involved in the decision-making process. These stakeholders have been portrayed in Table 5.1.

Table 5.1: Overview mainstreaming process stakeholder characteristics of the UWB Project

Stakeholder type	Organisation	Function organisation	Interviewees and function within project
Client	Municipality of Rotterdam	The municipality has their own knowledge and expertise, which was used for the preparation of the pilot and project management. In addition they also provided permits which were to be obtained through the municipality. Internally two different departments were mainly involved: - Stadsbeheer - Stadsontwikkeling	- Project manager - Project initiator
National Government	Ministry of economic affairs and climate policy & TKI – water technology	This ministry promotes the cooperation between research institutes and busineses. They offered a large amount of the funding along with some other partners within the cooperation. According to the RVO (Rijksdienst Ondernemend Nederland), the ministry offers funding for the TKI . (Top-consortia for knowledge and innovation). One of those consortia is TKI-Water Technology. [1] [2] THe middleman was the project manager of KWR which transferred information between the project group and the ministery. [3]	
	HHV Delfland	The waterboard had an advisory role in the project, as well as an initiating role. They were concerned with water quality as a part of their discipline with regards to the infiltrated water. The waterboard also played a role in the issuing of certain permits.[4] Furthermore, they are responsible for the surface waters in Spangen. [5] and they have provided a large sum of the funding.	
Consultancies	KWR-water technologies	KWR is a knowledge-institute. It generates knowledge concerning operating more water-wisely in the urban society. In this project they were responsible for the project management, preparation, and guidance [6] Furthermore, they were also responsible for the measuring of the water quality.	- Projectmanager - Co-projectmanager
	Wareco engineers	Wareco was responsible for the monitoring of the pilot, data had to be gathered and reported concerning the hydrological effects.	
	Codema BE - de Lier BV	Codema systems group was the installer of water buffers in the greenhouse-horticulture. They were responsible for the development of a control system and realization of pre-treatment and the wells.	
Start-up	Field Factors	Fieldfactors is the company that pioneered the idea of the UWB. In this project, they were heavily involved in the promotion and execution of the pilot. They also conducted the Cost-Benefit Analysis	Company founder

Stakeholder type	Organisation	Function organisation	Interviewees and function within project
Initiatives and institutes directly involved	Rotterdams weerwoord (Water Sensitive Rotterdam)	This is an cooperation between different parties that aims to make Rotterdam more climate resilient. This is done through consulting the municipality, but also other partners to change their attitude towards climate adaptation and water management.[7] The following parties are involved4: - HHv Schieland - HHv Hollandse Delta - HHv Delfland - Rotterdam Municipality - Evides Waterbedrijf	
	Natuurlijk Spangen	An initiative for more greenery in Spangen . It was relevant as Bluebloqs were applied which is a form of wetland. Furthermore, a water-column was applied for aesthetics.	
	Neighbourhood committee Delfshaven	Neighboorhood committee responsible for Spangen. Partially represented in Natuurlijk Spangen.	
	RoSa	Cooperation wastewater Rotterdam involving the following parties: - Municipality of Rotterdam - Municipality of Capelle - HHv Schieland - Waterboard Hollandse Delta - HHv Delfland (See separate mention) - Evides Waterbedrijf Evides joined the project through RoSa (Interviewee 9). Every year there are a couple of example projects which they adopt and zoom in on. The UWB was one of these projects. They are formally a drinking water company, but they do have an industrial water branch.	Water strategist - Evides
	STOWA	Similarly to KWR, the STOWA was involved in technical consultancy predominantly in the early phases of the project. Their explicit function was the explorative pre-study for the location. They did offer some funding as well [8]	
	Stichting waterbuffer	They had a rather free role, they were involved in spreading the findings and connections. They offered consultancy on legal procedures and permits. At the beginning of 2017, this organization was discontinued.	
Initiatives and institutes indirectly involved	RIONED Stichting CAS NKWK EIP	Within this project these stakeholders were involved for the spreading of the showcase and knowledge gained	
	Gemeente Den Haag Gemeente Rheden HHv Schieland HHv Krimenerwaard	These were partners that would later implement the UWB, and were more involved concerning their own districts for project locations.	

Based on their designation within the project and their interests, the involved organizations have been placed in a power-interest grid according to their role and stance in mainstreaming of the innovation (See Figure 5.3). This power interest grid is created with regards to the mainstreaming process, hence in the upper half of the diagram, the actors with the most power within the mainstreaming cycle applicable to this case study are found. The cooperation agreement was signed by the following parties, KWR Water BV, Wareco, Codema - B-E de lier BV, Field Factors, Municipality of Rotterdam, HHv Delfland, Evides, and Rioned.
These parties signed a contract in September 2016, and were continuously involved in the implementation process. Notable is the cooperation of Evides, which is the supplier of drinking water to the Sparta Stadium. Due to the cooperation through RoSa (and other cooperations such as Rotterdams Weerwoord and NAP), they have been been in talks with with HHv Delfland many times. As a consequence, it became easier for both to gain support from each other (Interviewee 9).

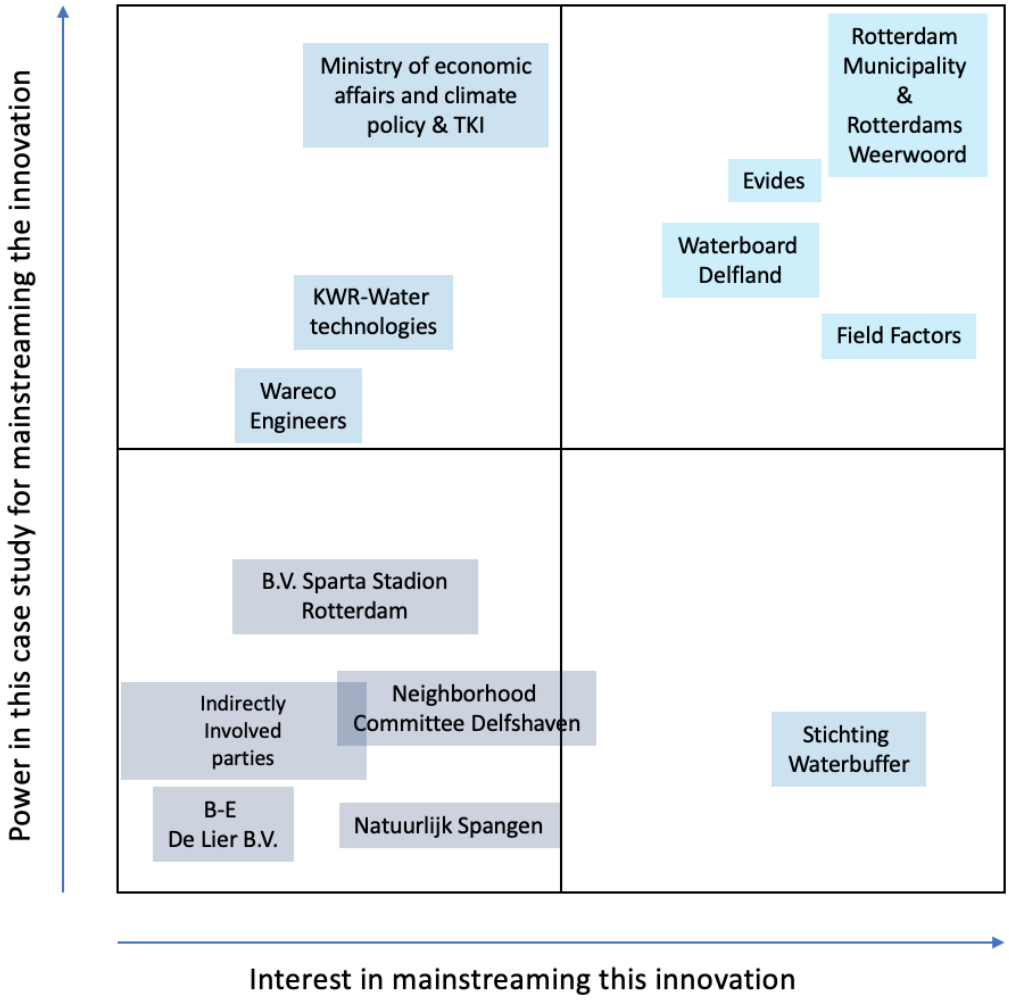

Figure 5.3: Stakeholders power-interest diagram based on mainstreaming in the case study of the UWB

This became evident from speaking to different people within the municipality (Interviewees 5 & 8). The ministry of economic affairs that provided the TKI-grant was not directly involved, the further use of this grant was arranged by KWR.
Codema B-E de Lier B.V. has only worked on this case as a contractor, they were working on the execution of the project. More specifically, their responsibility was towards realisation of the infiltration and extraction wells and pre-treatment.
The B.V. Sparta Stadion Rotterdam had to grant permission of execution at the location, however, internally they did not have further input. The neighborhood committee was mostly concerned with the aesthetic repercussions of the total construction. The indirectly involved parties were mostly interested in gathering knowledge and spreading this to other parties who could benefit from this technology.
Two interesting parties that showed high interest in this particular innovation are the STOWA and Stichting Waterbuffer. STOWA is a knowledge institute, they have many publications concerning

Applied Science within the water branch. Stichting Waterbuffer is an organization that has been involved in underground water storage in horticultural areas. In this case study, they were involved in selecting locations of interest within Rotterdam. Together with the KWR, they have appeared to be working on the underground infiltration of rainwater before this case (STOWA, 2016).
The interviewees finally considered for the case study based on their role within the project have been displayed in table 5.1. Initially, all of the stakeholders listed in the table above were considered. But from initial interviews with the project managers, it turned out that not all of them had such a prominent role in the implementation process as the documentation implied. Hence, recommendations from those key actors endorse the choices of the further interviewees.

5.3. ORGANOGRAM AND DECISION MAKING PROCEDURE

To form a better understanding of the implementation process, the decision-making process concerning SuDS within the municipality is elaborated in this section.
The organization of Rotterdam's municipality is structured into different layers (See Figure 5.4). The upper layer is mostly focused on the establishment and formation of policies, whereas the bottom layer is composed of various different clusters that function based on those policies. The total municipality of Rotterdam involves around 6000 workers, of which approximately 600 are working at the cluster Stadsontwikkeling. This cluster contains the engineering-related development and consultancy specialists, which is composed of many different teams per city region and discipline.

As in every municipality within the Netherlands, the council is chosen every four years and determines the vast majority of the policy program. The current council is rather enthusiastic about the sustainability transition, thus it allows for more flexibility amongst the involved clusters (Interviewee 1).

Their task is to make decisions on the proposals of the executive board, evaluate if the board executes decisions properly, and determine the distribution of possible expenses. The policy formation process starts with the formation of a coalition after voting results, which state their strive in their agenda. Proposals of the executive board and council are taken into account, where the annual budget is discussed for different programs. Civil servants (program managers concerning policies) use this information to develop the policies and budgets. Their propositions are sent to the council, which directs instructions to the executive board. The proposed policies can then either be accepted, declined, or amended to be proposed again. In short, the policy makers propose the budgets and policies, the council determines the budgets and the executive board establishes the policies. It was found that the applicable policy concerning the mainstreaming of SuDS, was the municipal sewer plan.

Policy formation does not only occur through those parts of the municipality, there are formal methods for external influence:

- Citizen initiatives such as a neighborhood council
- At the beginning of board meetings citizens can voice their opinions
- Citizens can partake in the advisory board or commission
- Citizens can become a member of a political party

The watermanagement discipline on practitioner's level is primarily distributed amongst three different clusters: 1) Stadsontwikkeling[9], 2) Stadsbeheer[10], and 3) The engineering consultancy. The

[9] Stadsontwikkeling = Urban development
[10] Stadsbeheer = Asset management

latter is a sub-cluster within Stadsontwikkeling (Interviewee 1). In Figure 5.4, these are displayed under the strategy preparation/execution section mainly under the cluster of city development. These are also the main clusters that are involved in the implementation of SuDS. Furthermore, the municipality of Rotterdam buys their own materials for projects hence their finance and purchase departments are also involved indirectly (Interviewee 1, 2). Within the cluster of Stadsontwikkeling, there are several sub-departments working together under the project management agency; the environmental (i.e. their own engineering firm), spatial and geotechnical department; the hydraulic engineering and civil infrastructure; landscape architecture and quality management (Gemeente Rotterdam, 2014).

"What sets Rotterdam apart from smaller municipalities is that they have their own engineering firm, in Rotterdam the internal knowledge concerning hydrology and geo-hydrology has been well developed. Usually, other smaller engineering firms are more focused on maintenance. In Rotterdam, there is a branch that knows their groundwater system really well" - (Interviewee 8)

This cluster gets their assignments from the Stadsbeheer department which provides the assignments and budgets. Where in this interaction, there is a possibility for Stadsontwikkeling to consult Stadsbeheer for the application of alternatives to traditional practices (Interviewee 1, 8).

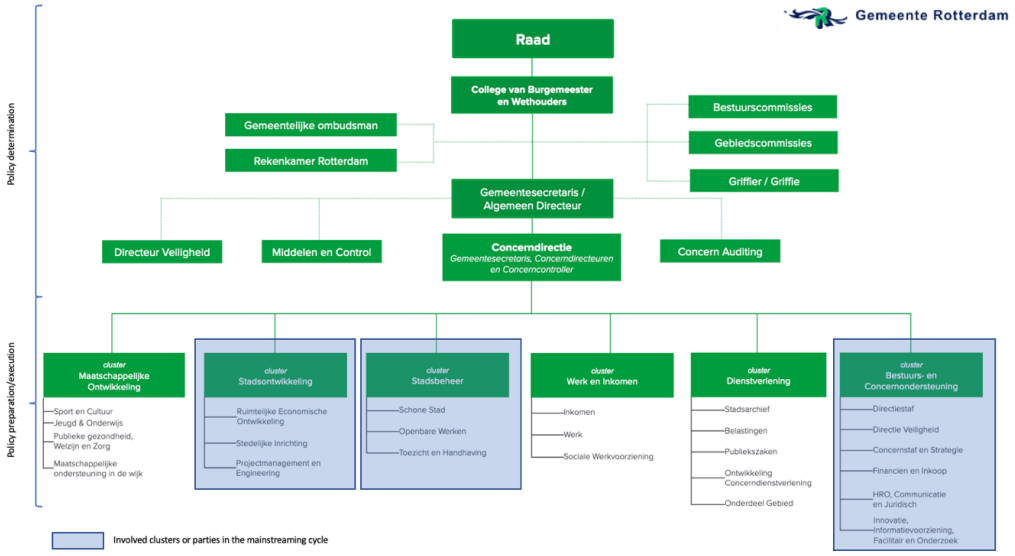

Figure 5.4: Organogram Municipality Rotterdam
(source: https://slideum.com/doc/9629191/organogram-gemeente-rotterdam)

According to interviewees 1 & 3, an innovation is usually proposed by colleagues at the practitioner's level according to an assignment that is formulated by Stadsbeheer. The usual way of implementation is to align this with scheduled work that would take place anyways (Interviewee 1 & 2). Permission is required from Stadsbeheer, as they provide the budget and agree to the maintenance of implemented assets (Interviewee 8). The council and board are not required to be informed or persuaded for this to happen. However, updates are given to the alderman who is concerned with

sustainability (Interviewee 6).

5.4. THE MAINSTREAMING PROCESS

In this section, the conceptual mainstreaming framework was applied to the first implementation of the UWB within the municipality of Rotterdam. The drivers, initiation-, planning-, and managing phases that were applicable to this case study have been reported. The interviews that have been conducted and their coherent codes are presented in appendix **G**, of which different quotes have been used to indicate factors.

5.4.1. DRIVERS

The drivers presented under this section are mostly on the organizational scale, these are exerted through the landscape on the regime in the form of external pressure.

HISTORY OF WATER TROUBLE

The city of Rotterdam has a history of dealing with water threats, whether them being of fluvial, pluvial, or coastal origin. In 1953 the big flooding disaster occurred, the Great North Sea Flood, which flooded 160.000 ha of land and left a total of 1835 casualties in the region of South-Holland (Rijkswaterstaat, 2016). This led to the formation of the Deltaplan in 1958, which marked the first plan concerning coastal flooding. In 1997, the Maeslantkering was completed which is part of the Deltaworks against coastal flooding. Around 1995-1997 the river Rhine started to become a threat, which resulted in different policies (e.g. the Room for the River act in 1997 and Flood Defence act in 1996) (Esteban et al., 2020).

The collective memory of those events is created through history lessons and memorials. According to Esteban et al. (2020), it was found that most cities that have had any experience with disaster have taken learning lessons from this to become more resilient. In essence, the policies have led Rotterdam to implement a climate-adaptive approach in their development of the city and water-related risk-management.

LOCAL POLITICAL ATTENTION: STRATEGY DEVELOPMENT CONCERNING URBAN WATER MANAGEMENT

In more recent decades, water issues associated with climate change have been finding their way towards the political agenda of Rotterdam. Interviewees 1 and 6 state that the drivers for climate adaptation stem from two different factors: 1) International image, and 2) the urgency to remain climate-adaptive by not only writing reports but putting them into practice. To underline the urgency, the following is stated by interviewee 6:

"Climate is changing and we require new perspectives on how to adapt. The drought and freshwater challenges are one, but we're not sure about the long-term scenario. We do however know that if we start experimentation when we need them, that we'll be way too late." - Interviewee 8

This mentality was established around two decades ago, one of the first pioneering documents in this regard was Waterplan 1 (WP1). This document was a short-term vision and, for the first time included plans for water retention. It is perceived as one of the first documents that broke through the stigma of the decision-making process of urban drainage solely lying with engineers (Dunn et al., 2017). Instead, landscape architects, spatial developers, and other disciplines became involved.
Amongst the timeline portrayed in Figure 5.5, a transition is displayed from water supply cities to water resilient cities. The real revolution concerning water issues started after the Architectural Bi-

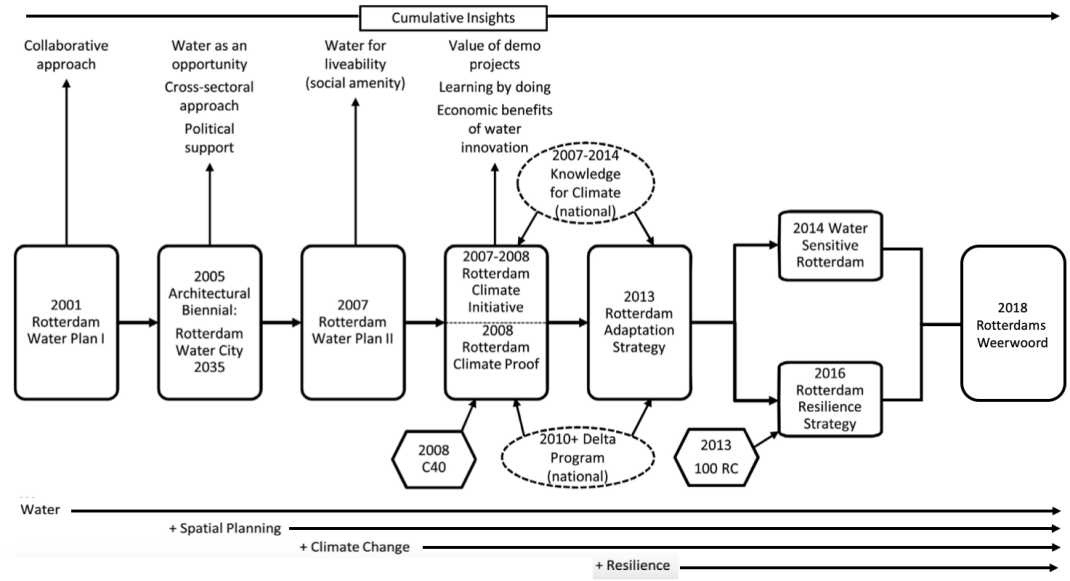

Figure 5.5: Policy and research initiative timeline, additionally WP2 was revamped in 2010. (Adapted from Dunn et al., 2017)

ennial in 2005 with floods as a theme (Dunn et al., 2017). One of the submissions was the “Rotterdam Water City 2035” vision, which made rough predictions for the climate change impact in 2035. Again, this was revolutionary compared to the WP1 and previous policies due to four reasons (Dunn et al., 2017):

- It was the first time a vision was produced for a long-term scenario
- It was a multi-disciplinary process, thus provoking experts of different backgrounds to pass knowledge to each other and make well-weighed decisions
- The vision was not meant for creating an official policy, it was more seen as a challenge hence decreasing the risk for those politically involved
- The study took place for a duration of two months, hence the lines were tight for decision making.

Through the input of this initiative, Waterplan 2 came forth (WP2), of which the mantra states: "Working on the water for an attractive city". WP2 created a foundation for a science-policy interface by involving more disciplines besides water engineers for water-related projects, such as urban designers, construction engineers, etc.

"Our management makes an explicit effort since the 90s with Waterplan 1,2 ... Top-down this is well organized, as there is a good cooperation with citizens, companies, organizations, etc. ... Our board supports this movement, and bottom-up it is well regulated ... " – Interviewee 1

This was the first official document released by the municipality that incorporated a long-term vision. Furthermore, the science-policy connection finally gained traction (Dunn et al., 2017):

1. The need for exploration of knowledge gaps such as climate uncertainties and their implications for certain districts
2. That the traditional approach to water management should be more open towards new ideas, technologies, and innovation in general.
3. The importance of showcase studies in the form of pilot projects was identified, to prove the concepts stemming from scientific knowledge through applications

The strategy of Waterplan 2 has evolved into updated versions of the strategy that are still based on those same three pillars: the RAS (2013), Watersensitive Rotterdam (2014), and the Rotterdam Resilience Strategy (2016). The latter were combined and formed Rotterdams Weerwoord in 2018 (Interviewee 1) (Dunn et al., 2017). These initiatives have led to previous projects being implemented such as wate square at Benthemplein which was completed in 2013.

"There wasn't any urgency to create water squares, there was however a pressure of lack of space and requirement of water storage. Can't we do that by improving the outdoor space? ... The strategy is rather the requirement of new innovation, than seeing innovations as the best solution" – Interviewee 8

This is a concrete example of the requirement of innovation due to present demands, therefore leading to the execution of a pilot.

STATE OF ART STRATEGIES, POLICIES, AND INITIATIVES AT THE TIME OF PROJECT

On the national level, the latest program of relevance for the UWB was the National Deltaprogram 2018 (DPRA). The DPRA is a policy that provides guidelines for spatial adaptation in local governments (i.e. waterboards, provinces, and municipalities) to be more climate resilient by 2050. In between goals have been defined, which states the following:

- Climate resilience should be a part of policies by the end of 2020.
- Locally linked governments should perform stress tests and risk dialogues with each other.
- By 2024 the municipalities should have integrated climate adaptation in their policies
- By 2021 the stress tests have been conducted and by the end of 2023 a realistic ambition has been formulated in policies

Since January 2021, as a part of the DPRA, the Impuls Regulation (IR) has started. This is a measure that makes it possible for municipalities to gain subsidy for climate adaptive projects. This subsidy will fund one third of climate adaptive measures that have been given. The grant is only be requested one time per year per work region from 2021-2023. A maximum of one third of the climate adaptive intervention will be subsidized.
No formal obligation is established between the national level and regional/local level, however, it provides guidance on the assembling of water planning and management. Interviewee 4, stated that these ambitions offer no obligation for municipalities to take any further action beyond the formation of plans. Additionally, Rotterdam was already ahead of the majority of other municipalities in the Netherlands, that national policies did not guide their progress.

"I do get triggered by the National Policies, that is for sure. But they do not guide me through projects or help me to take initiative ... Something that happens on the National level can be a driver to undertake action ... We have to participate, but we were already readily on the way and this will speed up the process." - Interviewee 6

On a local level, the only formal policy related is the Municipal Sewer Plan (MSP) [11], which is revised every 4 years (Interviewee 6, 8). This policy states that the municipality should explore innovations and knowledge development. For the project itself, Waterplan 2 (2013 – 2018) and Water Sensitive Rotterdam (2016) were the leading strategies for the water for the start of the project in 2016. The first document explicitly states: "searching for promising innovations and alternatives" and is backed by interviewee 2 which states that the current board has corroborated a significant budget towards climate adaptation. The successor of these strategies, Rotterdams Weerwoord, that the objective is: "to transform to a climate-resilient Rotterdam by 2025 and the scaling up that it requires into practical measures".

In the second document, more specifically a reference is made to the application of the Waterplan to the area of Spangen (**?**, 2016d).
The strategies were mentioned in the GP of 2016 - 2020, for which €200.000 was reserved every year for knowledge development (Gemeente Rotterdam, 2016b). Aside from knowledge development, a budget of approximately €70-75 million on an annual basis was specified for sewer management.
Thus climate adaptation is mostly arranged informally through strategies and the associated city goals, but formally integrated into the policies. The policies do open up doors for innovations to be implemented, however, no guarantee for mainstreaming is implied.

"For a city like Rotterdam, innovation is not applied because it fits into the policies. It is applied, because it can be part of a strategy. And when it performs well, it can become part of a policy. Thus the innovation itself is leading, as opposed to policies." - interviewee 8

Furthermore, the UWB was linked to the programme of water squares – innovative water buffering, which was part of the Rotterdam Resilience Strategy and Rotterdams Weerwoord (Gemeente Rotterdam, 2017b, Gemeente Rotterdam, 2017a). The goal of this program is to realize innovative multi-functional water storage, which at the same time is coupled to Rotterdam's Weerwoord.

SENSE OF URGENCY & KNOWLEDGE OF LOCAL CLIMATE CHANGE IMPACTS

An explorative study was conducted by Nieuwkerk et al. (2010), for which one of the neighbourhoods concerned was Spangen. They suggested that without any infrastructural changes, the pluvial flooding could increase to triple the number of streets as a result of a 50% increase in precipitation. These factors were also found to be the reason for implementing the UWB at Spangen in the project plan (KWR et al., 2016). Nieuwkerk et al. (2010)) also reported that the groundwater levels in the neighborhood of Spangen were comparatively lower than at the time of construction, thus implicating a possible problem for houses built on wooden foundations.

One of the measures recommended in this report was the realization of water squares and pilot projects, which according to interviewee 1, was part of the first generation of SuDS. Defining this generation to mainly allow for vertical drainage, while decoupling from the sewer system. The second generation of SuDS was described as those that offer secondary ecosystem services, such as

[11] In dutch: Gemeentelijk Riolerings Plan (GRP)

water treatment and redistribution.

There was definitely a water issue given this neighborhood, the canals were widened, a Water-square was implemented (Bellamy Square) and housing corporations have started buffering water - (Interviewee 6).

Historically, there was an ambition to realize the storage of 4.300 m^3 in the area of Spangen, the water in the neighborhood does not easily elude. This is largely due to the high fraction of paved area, and low situated land in combination with a high groundwater level.

However, due to not formally processing this issue, it was not recorded within the destination plan (Gemeente Rotterdam, 2016e). In 2016, the issue was brought forward in the destination plan for Spangen, which stated that a plan had to be drafted to solve the water issues in Spangen. Other than the water issue, no coupling of goals took place regarding the technology. As different solutions could have been applied that did not involve water re-use, coupling of the technology to other goals other than the water issue did not apply (interviewee 8).

5.4.2. INITIATION PHASE

In this section the initiation phase is further elaborated, it consists of the understanding, willingness, and enabling sub-phases. It differs from the drivers' section due to analyzing the receptivity on the practitioner's level rather than organizational scale.

UNDERSTANDING

The concept of Aquifer Storage Re-use, which describes the underlying process of the UWB, was originally an idea by Stichting Waterbuffer and the KWR. At the time Stichting Waterbuffer had committed itself to the development of ASR technologies, in the period 2012-2014 a few of those solutions were implemented in horticultural areas around Delfland and Zeeland (Gemeente Rotterdam, 2015a). The STOWA, KWR and Stichting Waterbuffer together initiated an earlier exploration study (STOWA, 2016). They were looking to promote this technology in the urban environment, eventually, it was presented to the municipality of Rotterdam (Interviewee 5).

"In Rotterdam, there is enough knowledge and capacity about SuDS, but we didn't know this application. Maybe this was the condition, that we have the base, and we can think along in the process" – Interviewee 8

As stated an issue at this point of implementation of SuDS was that the current solutions were focused on discharge of the rainwater through infiltration or sub-surface storage. Deep retention and re-use of this rainwater allowing for circular systems, had not yet been implemented. A major point of consideration was that at the upper ground layers the space was scarce due to cables and piping. Together with the pressure of higher groundwater levels, this made use of the deeper underground rather appealing.
To some degree there was knowledge on the systems from previous research concerning the functioning of these systems in horticultural areas by the KWR. However, there was knowledge missing concerning key figures surrounding the costs and benefits of the UWB. Furthermore, this would be the first time implementing such technology in an urban environment, thus there was a knowledge gap given the functioning within an urban setting.

"There was an indication of the reliability of the technology already, if you look at Amsterdam. You

can see the dune infiltration and withdrawal, which is a similar idea" –Interviewee 6

As the organization of Rotterdam is rather large, forming a uniform interpretation of the available information is not achieved easily. Innovations are shared with colleagues through Intranet when deemed interesting. Similarly, presentations are provided with (in)direct colleagues (Interviewee 6). The sharing of knowledge concerning SuDS is done through informal methods, which entails a non-structured approach for the sharing of this information. Currently, the municipality is working on establishing an initiative named Bouwstenen, which are factsheets concerning the state-of-art SuDS that have been applied previously (Interviewee 1 & 2). This strategy could be relevant for increasing the implementation of previous innovations, although the development of this plan is rather steady and slow (Interviewee 8).
Furthermore, it is to be said that the municipality has a broad arsenal of (inter)national networks for which they are able to learn from other municipalities, waterboards, and consultancy firms (Interviewee 1, 6 & 8).

WILLINGNESS

From correspondence documents provided it was found that the project itself took off back in around April 2015. HHv Delfland bridged the idea to the municipality of Rotterdam, where a small initial group was formed that had an open mindset to this initial idea. Delfland came into contact with the project initiator that gathered this group, this initiator was a well-known consultant with a background in water and climate resilience, due to his role in Rotterdams Weerwoord. Given his interests and activity within the municipality, it was easy for him to find colleagues with similar perspectives on the UWB concept. Intrinsic motivation was reflected back in their openness to taking risks, even though financial uncertainties and performance uncertainties were present.

These were colleagues from Stasdsbeheer and Stadsontwikkeling with a strategic vision on climate adaptation and colleagues from the engineering consultancy who had knowledge concerning geo-hydrology (Interviewee 8). Even though the municipality establishes itself as a pioneering organization regarding climate resilience through its policies and strategies, this was not evenly reflected back through the initiation and receptivity on the practitioner's level.

"Between the two involved clusters, there were colleagues that did not necessarily find that there was a value and urgency in the application of the system. We don't have the drought issue and it will not be significant in another 5 – 10 years. This raises a question if we want to experiment with innovations that may only become important in 20 – 50 years ... The more conservative thought in this is that we can wait and spend the tax money more frugal ... The other could say that we should invest, as this is not one million per year " – Interviewee 8

The above comes down to the dilemma of whether precautions should be taken for possible future scenarios or to observe if which scenario takes place and to act on it later. And even though long-term thinking is pushed on the organizational scale, this is where it could be improved on practitioners level.

"Some could say... I've done this project 30 years like this, why would I change this? ... This could of course cost more time and effort to make a change" – Interviewee 6

"There is a need for requirements, a toolkit that offers what is possible: water squares, crates, etc ... At the same time, you see that consultants that know less about the topic revert to the current tools,

which may be a barrier to implementation of innovations" – Interviewee 2

The second argument of practitioners against the implementation came from both clusters of Stadsbeheer and Stadsontwikkeling. The developers were unfamiliar with the innovation, which causes some colleagues to be hesitant. This is why the municipality is experimenting with tool kits which are databases that contain information on SuDS that facilitate their implementation. For this project, this was not the case. An indirect risk analysis had to be conducted to find the colleagues that would be receptive to the pilot of the UWB.

In previous projects concerning water innovations, this initiator was also involved as a key person. Thus, the ideas that he presented were coming from someone who had built a reputation within the organization, which builds trust. The above mostly comes down to having the right internal network and knowing who to approach (Interviewee 6, 8). This is not the standard procedure though, it is a rather informal way of working which lowers the bar of initiation.

Given the size of this municipality and its structure, it doesn't seem likely that in the short term this will become the norm as there is a large bureaucratic component involved. However, it was said that in this stage of experimentation it is not necessary to persuade all colleagues of what is right. The support should be rather deep and intense rather than broad, which would lower the chances of success (Interviewee 8).
"We haven't asked anyone for their opinion, we have told the involved management the principle and to which issue it contributes. ... It is a matter of what you present, if you present the system within the context or just the system ... In between different meetings were required to keep everyone on board with where the project was heading" – Interviewee 8.

ENABLING

After this initial group of people within the municipality was gathered, a feasibility analysis was drafted. The feasibility analysis consisted of: 1) an exploration of potential locations for infiltration, 2) the elaboration of the UWB at one location, and 3) The GO/NO-GO for preparation and realization (Gemeente Rotterdam, 2015b). Internally the following parties were involved in this trajectory:

- Stadsontwikkeling - Project manager
- Stadsontwikkeling - Geohydrologist
- Stadsbeheer - Water - pumping stations and sewer systems
- Stadsbeheer - Piping systems - Cables and Pipes in subsurface
- Stadsbeheer - Consultant social aspects in neighborhood

The first two steps (feasibility analysis) were estimated to require a budget of €70.000 (Gemeente Rotterdam, 2015b), which was estimated later to be €45.000 in the official project plan (Gemeente Rotterdam, 2015c).
The choice of locations was based on the chance that utilization at a certain location would be beneficial. Such chances were most likely found in areas with wooden foundations, with low water levels where the UWB technology could mitigate potential damages. Consolidation was a second matter, as the UWB could marginally increase phreatic levels to compensate. However, this was found to be minimal. Water quality was also of importance, concerning combined sewer overflows on surface water. Concerns for the were anticipated to be the potential pollution within deep aquifers or too high increase of groundwater levels leading to seepage.
In the project plan, the provision of grants by different actors (including involved parties) was already taken into consideration. In practice for the first two steps, important parameters related to

the geo-hydrological properties, hydraulic properties, and quality properties, as well as GIS data for retrieving the water demand per area. The demanded GIS data was found to be applicable to the whole city rather than to neighborhoods. During a period of 4 months between November 2015 and February 2016 the majority of the required data was gathered (Gemeente Rotterdam, 2015a; Gemeente Rotterdam, 2016a). The geotechnical, hydraulic, and spatial parameters eventually determined a list of 10 potential locations, of which three stood out.

The initiator was aware of the water issues in Spangen, thus he already had conversations surrounding Spangen and Sparta. This comes down to having the internal and external network to support such choices, eventually, Spangen came forward as the choice of location (Interviewee 8).
As the project became more concrete, the choice of GO/NO-GO could take place. A draft design was needed, for which an indication on the following factors was provided to pursue the project further (Gemeente Rotterdam, 2016c):

- Investment costs + Maintenance costs
- Risks of the installation
- Technical feasibility
- Spatial feasibility

The maintenance and investment costs were portrayed in a project proposal by Field Factors and KWR. The budget that included the designing and execution costs amended to €175,000 (Field Factors, 2016). Furthermore, the full construction was expected to be approximately €400,000 This was followed by a draft design that was finally pursued by the project team.

"As the project became more practical, people increasingly needed to be convinced or informed. People tend to fall back to the known, as it has been done before." - Interviewee 6
The other colleagues from Stadsbeheer had joined the project in this stage, where more critical views came forward which had to be convinced for permission for implementation:

- Two important documents have been released in this timespan for the GO/NO-GO, which concerned the exploratory research of the area in Spangen and the action plan. In these plans, a reduction in the drinking water for the sprinkling of the fields was anticipated of approximately 6.000 - 7.000 m^3/year (€5.000 per year). The spillway at the Spaanse Bocht would still be present. However, the load at the time was too high for the available storage. Hence, the pressure on the Spaanse Bocht had to be decreased as the spilling was not always a possibility (Interviewee 5). This would lead to a decrease in pump usage towards the Spaanse Bocht of rainwater would reduce costs by €250 euros/year. Within these documents, different alternatives have been considered concerning the factors above.

- The concerns were voiced given the cables and piping systems by the Stadsbeheer, as this project was going into the deeper underground in-situ data was required for further continuation (Interviewee 6). This data was mostly gathered through the GIS archives of the municipality itself.

- By Stadsontwikkeling there was opposition regarding the usage of groundwater drainage in surrounding areas within a range of a few km. This could move the fresh-water aquifer and cause consolidation or local water trouble (Interviewee 6). This was a barrier that was mostly overcome by arguing over the long-term ambitions of the city and the minor implications this would have.

- The landscape architects from Stadsbeheer were not convinced about the integration of the UWB into the outdoor space (KWR et al., 2016), which was a difficult challenge to overcome (Interviewee 6, 8). There were certain pipes that were scheduled to be above the surface level which would have a negative impact on the surroundings and could be susceptible to vandalism. This was a new solution of which they had no knowledge, so they had to be presented with an overall image (Interviewee 6).

- Within Stadsbeheer there was skepticism about the use of the construction, particularly the urban wetland. The managers were concerned whether the plants would remain in place as Sparta would play every two weeks (Interviewee 6). This required convincing from different colleagues that could elaborate on this issue better. Eventually, it was resolved by placing this construction in a non-accessible area for the public

- Stadsontwikkeling has a lot of technical knowledge as mentioned earlier, however, they lack knowledge concerning the treatment of water and the proposed technologies that were involved. According to interviewee 8, there was a procedure in the decision for the maintenance of the construction between Stadsbeheer and Evides. Evides is responsible for the drinking water delivery to Sparta, however the municipality stores the water in the aquifer, therefore an agreement about the division of responsibilities had to be established. Eventually, Stadsbeheer decided to outsource the maintenance of the sources and installation to Evides (the drinking water company), while doing the maintenance of the crates and Bluebloqs by themselves. Evides agreed to take the maintenance upon them of the infiltration well and tank (Interviewee 8).

- There was a certain discourse concerning usage of crates, in the past crates were advised by Stadsontwikkeling. This was not coordinated accordingly with Stadsbeheer, hence the cameras and wells for purging were not placed properly, this has gone wrong in the past. The lesson drawn from this better strategic plan and involve Stadsbeheer in earlier stages, had this been done earlier this resistance that was formed wouldn't have been in place (Interviewee 2).

- The budget was a very important factor, the initial costs were made for this phase. However, they were only a fraction of the execution of the full project loop. Hence, different subsidies were required for the execution of this project. HHv Delfland and KWR-TKI have provided a significant amount of funding for this to take place, as well as Stadsbeheer which had to give permission and allocate a budget to it. Without the extra funding that was given, the project would not have taken place (Interviewee 6, 8).

- The project budget was determined to be €1.000.000. The total investment of the municipality attained to ± €800.000. The remaining costs were mostly covered by the TKI-Grant, Waterboards, and other partners (KWR et al., 2016). This is different than what was specified in the initial proposal by KWR and Field Factors, which had only focused on the ASR technology where the costs would be approximately €400.000. The majority of those costs were attributed to the investment in the large storage. This was also confirmed by interviewee 6, which stated that the costs were higher than anticipated due to the buffer that had to be implemented. An increase of the budget had to be requested from Stadsbeheer (Gemeente Rotterdam, 2017a).

5.4.3. PLANNING

Eventually, a final design was established, which divided the full construction into different compartments. The municipality was responsible for the buffer to be realized, Field Factors designed the Bluebloqs and Codema was responsible for the practical design of the infiltration facility (Interviewee 5). The project manager assigned by KWR facilitated the integration of the whole construction together with the project manager of Rotterdam (Interviewee 5, 6).

An important notion around the implementation was that the costs of water storage are largely for the municipality and Delfland (Project team, 2016). The funding of TKI was established through KWR, which was a grant predominantly focused on research on the ASR technology in urban settings. Evides, made known that they were interested in enabling a fund concerning the project too. What became evident from the project plan is that there were significant research gaps that the involved parties were willing to explore, this testifies in the trust they had in the technology and each other given it being a rather new project.

"Most of the parties cooperating outside of the municipality were strangers, this made the intensity of meetings rather high. ... In between I have had many bilateral conversations to keep everyone on board ... Eventually that will pay off and create trust between people thus enhancing the continuity within the project" – Interviewee 8

Interviewees provided arguments that the cooperation was mainly project-orientated as the time restrictions made the process very intensive. The identification of stakeholders at Sparta was straightforward, no hardships were found. As a usual per project, the difficulty is more so found in speaking to the right people.

"Instead of keeping people to their words they made a while ago, we let the alderman call the director of Sparta to discuss things straight to the point" –Interviewee 8

The Cruyff Foundation and Sparta were not interested in the technology itself (Interviewee 6, 8), as long as they would still get their water. But as mentioned before, the technology was an addition rather than a full replacement of the current drinking water system.
Their requirements were that no parking spots were lost in the process, and that it was executed within a less intensive period for the stadium (Between the Eredivisie and Eurocup soccer for Women). At this stage different options were considered for the re-use of the withdrawn water from the aquifer: Water for the fire department, water that could be spilled on the Spaanse Bocht, water for the Ice-skating on the parking spots when it's cold, and re-use for Sparta on the fields (KWR et al., 2016). For which the latter was chosen eventually, based on the water demand from Sparta and the choice of location. The use of the water was of course subject to the quality and characteristics of the water that was re-used for watering the fields.

For the other surrounding stakeholders, the outdoor space is improved which is relevant for Natuurlijk Spangen and the Neighbourhood committee as greening is increased through the application of Wetlands and a fountain in the form of a pillar. The neighborhood committee was also involved in the choice of the water column for the outdoor space.

The involvement of TKI and Delfland in the funding caused new boundary conditions for the project: 1) A time limit of two years from planning to execution by TKI, 2) the monitoring results should be updated on a website for TKI for 5 years and 3) Delfland wanted the water to be visible for the general public.

In March of 2017, the final project plan was created. The wishes of the opposing parties were taken accounted for in this project plan.
1. Fitting into outdoor space 2. Prevention of disadvantages to surroundings 3. Dealing with urban pollution in run-off 4. Minimizing probability of failure, so no water issues happen due to heavy rainfall.

These issues all taken into consideration in the feasibility analysis. The minimization of the probability of failure was accustomed for by having a backup (Interviewee 8). The backup consisted of two parts: 1) Evides already had a drinking water delivery system system in place at Sparta, and 2) the current combined sewer system remained in place with the spillway (KWR, 2016). In case of the buffer being full, the in-situ sewer system would just spill the excess water on the Spaanse Bocht (See Figure 5.1). This sewer system was applied for the UWB for transport of water, however, the combined-sewer system had small tears which allowed the groundwater containing iron to get into drinking water. An additional filter had to be implemented at the treatment facility to counter this effect (Interviewee 6).

HHv Delfland and the Municipality carried the responsibility for obtaining the required permits concerning the Water Law and the Soil Protection Act. Although these permits were provided by those same parties. Permits were required for the drilling of the infiltration facility, which concerned an environmental permit that this activity would not pollute the soil and groundwater. The main permit concerned the infiltration and extraction of water of the aquifer. Through the internal network, it became apparent that a colleague was already working on such a permit around the Botlek, this enabled an advisory role from this colleague towards the HHv Delfland (Interviewee 8). The permit was of course subjected to a pre-study of the effects of this technique on the surroundings (KWR, 2019). As this was a permit that had not been issued before, it was difficult to come up with the boundary conditions (Interviewee 6). Stichting Waterbuffer issued assistance in this process as well.
Furthermore, as this was a new innovation within the municipality external parties were required to be able to make an estimate of the time it takes to set up such a fieldwork system (Interviewee 8).

5.4.4. MANAGING

EXCECUTION

The execution came with fewer difficulties than expected, the supervision in this phase was divided amongst the municipality and KWR (interviewee 5, 6). The buffering of the rainwater was mostly supervised by the municipality of Rotterdam, the other components of the installation were outsourced to the KWR (interviewee 5). In the project plan, the soil structure was retrieved through probing measurements. With these measurements it is impossible to retrieve the full soil structure in every spot, hence some unforeseen circumstances concerning the soil happened during execution. In the project it was chosen to create an underground water technical space, this had already been designed by the contractor. Due to this extra temporary water storage that had to be created, the investment costs became significantly higher (Interviewee 6). One problem is that this space is under the groundwater table and at the time it was not fully waterproof (KWR, 2019). Hence, when testing the crate system, the system became damaged as a consequence. However, this is a problem that could have occurred with a traditional system too.

MAINTENANCE & MONITORING

KWR (2019) states that the monitoring phase took place from early 2018 till mid-2019. However, from the permit, there is an obligation to report water quality results periodically to the Waterboards and sensors that report other parameters automatically (Interviewee 9). As a consequence, the monitoring will be executed for 40 years as the permit states. The concrete monitoring plan and division of responsibilities was determined after the choice of location and final design (Gemeente Rotterdam, 2017c). A concrete distribution given the maintenance of the installation and its different parts had to be created. Part of the maintenance was outsourced to Evides. Furthermore, Rotterdam Municipality takes care of the Bluebloqs and Cratefield through the department of Stadsbeheer. The monitoring goals were documented as follows:

1. Determining the functioning of pre-treatment and infiltration water quality
    - Before realization different samples of flowing rainwater have been analyzed, different substances were found that did not fulfill the requirements for infiltration: Suspended Solids, zink, and PAH's[12]. From the treatment steps of the UWB, these were found not to be an issue after installation (Gemeente Rotterdam, 2017c).
2. Determine the functioning of infiltration- and extraction system
3. Determine effects on the surroundings
4. Determine the effects or quality of produced water in public space

The maintenance took spanned the following activities (KWR, 2019):

- Monitoring the system (weekly base)
- Keeping the Bluebloqs filter clean (It is susceptible to trash that gets blown in there by the wind and youngsters that throw bricks)
- Keeping the vegetation healthy and neat
- Cleaning of the infiltration well with Na-hypochlorite, as this turns helps to regain the initial infiltration capacity. It was found from this addition that mainly biological pollution takes place in the well.
- From the permit every two months samples are taken to check the quality of the delivered water (Interviewee 6).

EVALUATION

Technical conclusions and cost-benefit analysis results

Around two years after the finalizing of the execution phase, different evaluation reports were released by Field Factors, KWR, and Wareco concerning the monitored activities. These were produced on their websites and widely spread across other platforms such as climatescan.nl

The water quality was monitored in different parts of the construction. For the to-be infiltrated water, different samples were taken of the groundwater, rainwater, infiltration water, extracted water, and the tank. The parameters which were checked were identical for both phases.

These parameters were according to the requirements that were required for sprinkling by Sparta B.V. Due to the mixing of un-deep groundwater in the crate field, the characteristics of the water

[12] PAH are Polyaromatic hydrocarbons, in Dutch: PAK: Poly Aromatische Koolwaterstoffen

were not the same as regular rainwater. The parameters concerning this groundwater are found back in higher concentrations of C, Fe, Na, Mn, HCO3, and NH4. The higher concentrations of Fe and Mn were potential threats that could lead to the clogging of the infiltration well. Using The frequency of infiltration was 1 time per month, which is resembled by the frequency water quality measurements. A reference is made to the horticultural areas where this technology is monitored approximately 2 times per year (summer and winter).

In earlier documentation it was mentioned that experts considered there would be no microbiological risks using the sprinkled water on the fields (Gemeente Rotterdam, 2017c. Interviewee 9, has confirmed that research has been conducted concerning this matter around 2019.

According to the monitoring, not all the rainwater of the area of 4.5 ha seems to reach the buffer. This could be due to the fact that certain parts of the area are not linked to the old sewer system, which therefore doesn't drain into the buffer. Hence, the buffer is over-dimensioned, which could mean that for extreme rainfall events that are higher than anticipated the buffer could offer a solution. However, it also means that less water can be delivered from the UWB to the Sparta Stadium, solely based on the system.
So far, approximately 10.000 m^3 treated rainwater has been infiltrated in the lower 7m of the aquifer, of which 2.500 m^3 has been extracted, which means 7.500m^3 is still available for later extraction (KWR, 2019). The use of the buffer went slowly as the groundwater is rather brackish, the freshwater aquifer had to be filled first. After equilibrium is formed extraction can take place on a larger scale, however, due to groundwater flow, it is not to be expected that the aquifer will remain in place. Hence, the infiltration and extraction rates may vary slightly in the long term (Interviewee 9).

It was found that due to the large capacity of the water buffer, the use of the Spillway at the Spaanse Bocht will not be necessary, which is in accordance with the wish of de-loading the Spaanse Bocht (See section 5.4.2). Apparently, during monitoring, it was found that the soccer stadium is not connected to the waste-water sewers instead of rain-water sewer (KWR, 2019). This means that the use of a spillway is not possible. Hydrological changes due to the UWB, were negligible in terms of water levels, the piezometric level was elevated as opposed to before infiltration (KWR, 2019). Wareco (2020) states that this change of water level is mitigated due to a large clay layer being in place.

Cost-benefit analysis
The second document concerns a cost-benefit analysis which includes a life-cycle assessment of the full structure, on average this reads 40 years. The initial costs were as indicated in the final project plan as approximately €1.161.000. For the regularly scheduled maintenance, this would be €360.000 for 40 years. The capital maintenance is estimated at around € 82.150 (Field Factors, 2020). The latter costs are highly uncertain, as now water with a lower quality than drinking water is delivered for the same price (Interviewee 8 & 9).

Based on the water delivery alone over 40 years, the benefit would be a third of the total costs listed above.

"In the short-term, these costs are hard to estimate, however, no large quantities of water nor high amounts of money are involved. It is about a couple of thousand euros per year .. in addition, due to a malfunction it could be that costs may rise 20% on an annual basis. This should be considered by the municipality and Evides" - Interviewee 9

Taking indirect benefits into consideration, mainly the spatial quality improvement (Increase in

%WOZ and retention capacity to prevent water issues), an evening out of the costs/benefits is possible (Field Factors, 2020). Two key points are that the full theoretical de-coupled area is taken into consideration for this calculation and 12.000 m^3 of extracted water per year, which is different than the monitoring results in KWR (2019). The benefits in the long-term are still uncertain, however, the execution of such an analysis does offer insights on how it could compare to using traditional methods.

A final notion towards this CBA is that the different stakeholders did have different intentions, Evides, KWR, and Delfland were predominantly interested in the knowledge gained from this study (Interviewee 5). Rotterdam Municipality was eager to learn if this innovation could be implemented again and Field Factors was mostly interested in replication of this experiment (Interviewees 6, 8, 10). There was no urgency to apply this innovation, however, it could help to anticipate a question that could become very relevant in 2 - 3 decades (Interviewee 6).

Upscaling potential

Most participants and reports are optimistic about the upscaling of this innovation, either in the short or long term. However, interviewee 5 has mentioned that if you only judge by the cost-perspective, it is a rather expensive solution. Both interviewees 6 & 8 have made it known that without the extra funding through the cooperating parties that were given, the project would not have taken place (Interviewee 6, 8).

"Eventually it is cheaper to just spill the water away .. But if that is better.. Rotterdam has their issues with decreasing water levels and if you keep pumping without returning it will eventually pay the price" - Interviewee 5

Both Field Factors (2020) and the interviewees 5 & 6 found that costs could be significantly cut down if the temporary water storage (crate field) could be substituted by different storage methods such as current canals or empty underground parking lots. Furthermore, the space used for the initial treatment through Bluebloqs requires a lot of space, it would be beneficial if the storage and filter could be combined (Interviewee 6).

Interviewee 1 & 6 have mentioned that once the first implementation has taken place in practice, the second one becomes easier. However, one single measurement is not a sufficient. According to interviewee 8 a few more pilots have to be realized to come to conclusions. Which are taking place at the moment in different locations as mentioned in the introduction of this case study.

A major factor that has been mentioned is that there is potential for upscaling, however, this may take a while after the pilots for two reasons. The drinking water in the Netherlands is very cheap currently, the delivery of the recovered water is more expensive. Hence, it may take time or switching of locations to approach a higher adoption rate (Interviewee 6).

"For pilots, there is a significant budget, for large-scale practice not... This is because we do not know what will happen ... This may be a fallacy, as in the pilot is realized and working well, upscaling becomes an immediate thought ... We need to be patient and see how it works in the long-term and in a scenario of 30 years before we scale up" – Interviewee 8

The second reason named above is that there are too many uncertainties as of now and this is a learning phase. When looking at the type of innovations that have been around longer (buffer/storage of run-off), the municipality has more experience. Hence, the procedure becomes similar but smoother

as these have been present for a while.

"The need for mainstreaming in Rotterdam is large ... We went from 40 kinds of streetlamps to 5 for easier choices ... We have a test street ... If it's proven that an alternative is good for a standard application, this may take a few years" – Interviewee 8

Furthermore, a paradox has been found in the standardization indicated by interviewees 2 & 3. They acknowledge that there is a need for standardization of innovations, but you do not only want to be successful in the short-term in the standardization, which means you have to keep up up with the latest innovations offered by VPdelta. There is a chance that if you standardize the current innovations, with the current technical developments within a few years, they may age rather quickly (Interviewee 3). This in turn could mean that there is less room for exploration of the newer innovations.

5.5. KEY POINTS OF CHAPTER

A summary of the identified factors and whether they function as drivers or barriers has been placed in Table 5.2.

	Drivers	Barriers
Drivers	- Strategy that highlights importance of experimentation with SUDS - Development of strategy that creates choice manual for suds - Policies that specify budgets for SUDS through knowledge expansion - External funding was available which played a decisive role	
Initiation	- The municipality actively introduced to the concept by a knowledge institute and the waterboard through a mutual network - The initiator was persisting, persuading, and took initiative. He had his own network with likeminded individuals which added to his trust. - The municipality has its own fully functioning engineering consultancy with many disciplines. - Permission is granted on practitioner's level. The total costs that were approved were ± €800.000 for the municipality - The stocking of materials is executed by the municipality itself. This minimizes errors concerning applied materials.	- There was opposition by Stadsontwikkeling: - There are workers that have optimized their own work routines and do not want to deviate - The dilemma of acting now or later for coping with climate change - There were high uncertainties regarding the performance and hydrological effects for which studies had to be conducted. The initial costs were already ± €45.000.
Planning	- An area that portrayed water issues was available - The permits were granted by the municipality and the waterboard. Both were part of the project team - The project team had enough expertise and skills to complete the design. There was trust in each other's capabilities.	- Opposition by Stadsbeheer: - The construction had to be altered as the landscape architects wanted the construction to better fit the environment. - Stadsbeheer did not have the knowledge to maintain the full unit, hence this was partially outsourced to Evides
Managing	- Awareness was created through documentation concerning the water quality, costs and benefits, spatial benefits an maintenance. - The project group established two other locations for implementation since the finishing of this project.	- The total costs were found to be rather high for a storage solution. - Drinking water is too cheap in the Netherlands for this solution to be viable. Sparta is now paying a higher price for lower quality water. - The monitoring process will take long before upscaling within the municipality will occur.

Table 5.2: Summary of the drivers and barriers in the UWB project

6

CASE STUDY – BUFFERBLOCK – CAPELLE AAN DEN IJSSEL

In this chapter, the case study of the Bufferblock is explained, in similar manner as in Chapter 5. In section 6.1 a brief introduction is given to the case study, section 6.2 contains an analysis of the most important stakeholders, section 6.3 describes the decision-making procedure per municipality, and section 6.4 describes the case studies according to the mainstreaming framework. Thus dividing the mainstreaming process per case study into different phases, here drivers and barriers are brought forward. In the last section, the barriers are identified based on the documentation and semi-structured interviews that were taken into account. In this section many references are made to the interviewees, for the roles of the interviewees please refer to table 4.3.

6.1. INTRODUCTION OF THE CASE STUDY

In early 2020, the project named WaterWeg Capelle took place in the Arica, a neighborhood located in Capelle aan den IJssel. In the project, different climate-resilient technologies were applied in this neighborhood (See Figure **??**). The main goals of the municipality concerning this project were implementation of: 1) Light elevating materials and 2) a water storage capacity. These characteristics were both a part of the solutions offered by the Bufferblock technology..

The Bufferblock is a storage solution that enables rainwater to be stored and slowly seep into underlying soil. Essentially, it is a hollow concrete block that is situated on a bed of sand with a layer of permeable geo-textile (See Figure 6.1). They are placed at the surface, where they in the case of the Arica they are also connected to the local combined sewer system. The Bufferblocks have been implemented in a residential street for disconnects a surface of 600m^2.

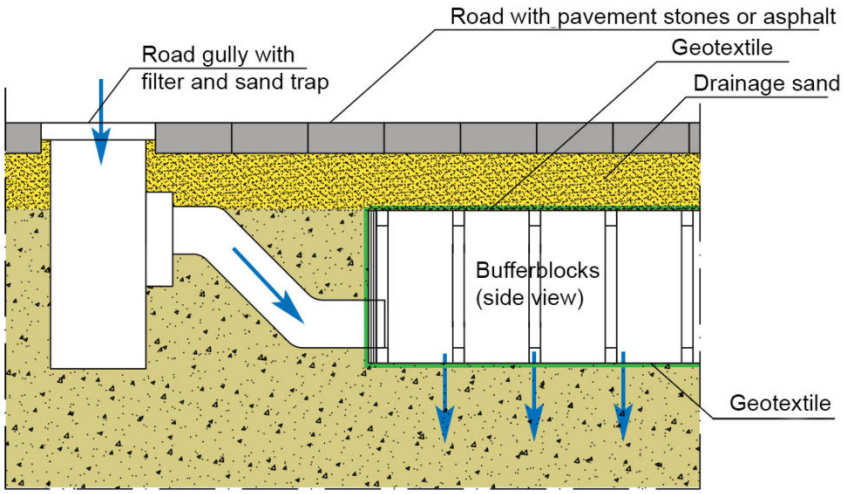

Figure 6.1: A technical overview of the Bufferblock system in place (source:https://www.bufferblock.nl/en/solutions/)

The rainwater is drained into the storage space in the Bufferblock by using gullies. The water is then drained into the regular sewer system with a delay caused by the intermittent storage. Finally, it is spilled on the surface water. As small spaces are present between the blocks, drainage towards the subsoil is facilitated which prevents the water levels from dropping.

6.2. STAKEHOLDER ANALYSIS

In similar manner to the previous case study, a stakeholders analysis is conducted to gain insights on the influence and importance of the involved parties. Through initial communication with the municipality, a sheet concerning the stakeholders was provided which has been translated into Table 6.1.

Table 6.1: Overview mainstreaming process stakeholder characteristics of the WaterWeg Capelle concerning the Bufferblock

Stakeholder type	Organisation	Function organisation	Interviewees and function (within project)
Client	Municipality Capelle	The municipality of Capelle was the client in this project. Internally two clusters were involved: - Stadsbeheer - Stadsontwikkeling Furthermore, the permission of the Alderman and municipal secretary were required. As well as their presence at multiple meetings.	Projectmanager SB - Engineering Consultancy Projectmanager SB - management
Consultancy	Tauw B.V.	This organization is an engineering consultancy that had experience with different innovative climate-adaptive solutions. They have consulted the municipality in their choice of innovations and development of concrete implementation.	Consultant
Government	HHv Schieland and Krimpenerwaard (HHSK)	The water board had an advisory role in this project given water issues and groundwater. Specifically for Bufferblocks, the surface water effects were more of their interest.	
	Interreg 2 seas mers zeeen STAR2C	The STAR2C's project addresses the lack of implementation faced by their stakeholders in the delivery of local action to build adaptation capacity. [1] The program itself is partially financed by the European international development fund. The program issued a grant to the WaterWeg project, which of course came with some requirements: a project deadline (2021) and a requirement of knowledge dispersion.	
Startup	Bufferblock B.V.	Bufferblock B.V. is the company that came up with the idea of Bufferblock solutions. There are multiple systems available on the site. This project was the first time where the Bufferblock was implemented outside of the Waterstraat on the Green Village.	Company founder
Contractor	Aannemers bedrijf Blijdorp B.V.	As far as known the contractor had no further input in the project apart from execution of the plans.	
	RoSa	See table 5.1 Similarly to the UWB, this was a project that was adopted by the RoSa. Mostly the waterboard HHSK was involved.	
	Deltares	Deltares at the time was creating an adaptation catalog, it provides the consequences related to certain climate adaptive measures.	
	Citizens IBOR-project	This project took place in a residential area, hence the citizens were involved through a citizen initiative that was formed during the project.	
Indirectly involved parties	TU Delft - TNO	The TU-Delft and TNO were listed in the stakeholder document. However, no concrete link apart from the Waterstraat has been found which is linked through VPdelta to the TU Delft.	
	Platform Slappe Bodem	Platform Slappe Bodem is an initiative that is concerned with ground-level subsidence. It is a knowledge distribution initiative concerning this problem. There is a large network involved, including members and partners. The organization spreads knowledge actively through projects conducted by the parties involved. Involved parties span amongst adjacent municipalities, provinces and waterboards, and Rijkswaterstaat	

Similarly to Chapter 5, they have been placed in the power-interest diagram that enables identification of the more important interviewees (See figure 6.2).
For the first iteration in the mainstreaming cycle, the municipality of Capelle did play the most dominant role by allowing for this project to take place. The Star2C mainly formed input in the project by the issuing of a grant and was not involved in any other way throughout the project.

Deltares was assigned by the municipality for the development of the adaptation catalog based on the experiences they have gathered through the project. In this document different possibilities of

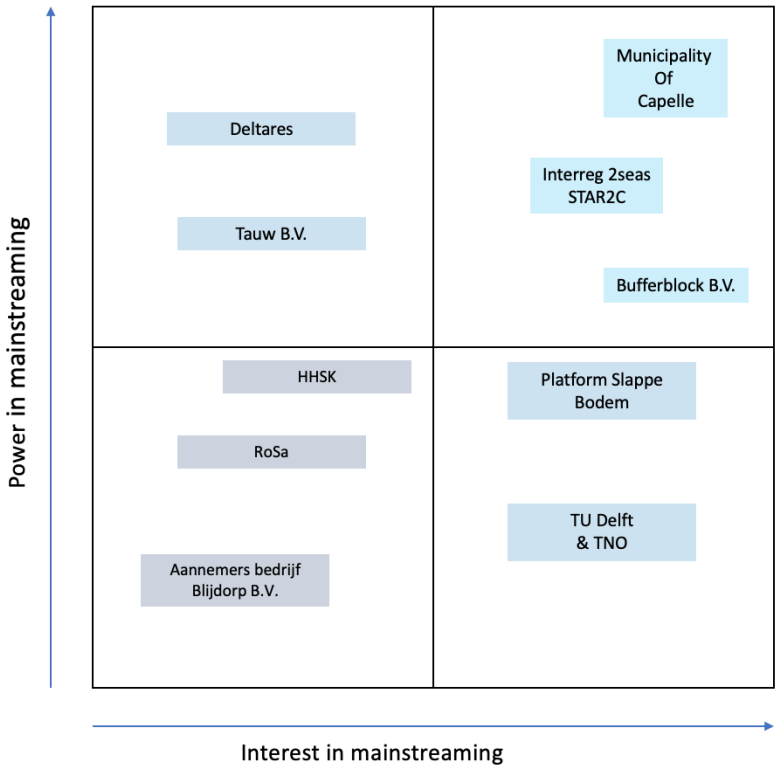

Figure 6.2: Stakeholders power-interest diagram based on mainstreaming in the case study of the WaterWeg

choices are presented which can be of relevance for decision making with regards to future scenarios (Interviewee 9). They were not directly involved within the implementation of the Bufferblock, hence no interviews were conducted within this organization.
HHSK was asked to be present during the involvement of the citizens and during the visit of the European partners within the Star2C's-project (Gemeente Capelle , 2018). Opposed to the UWB, this is a rather straightforward solution that is applied at the surface level, which as stated earlier is the responsibility of the municipality. Large changes in surface water levels were not anticipated by the municipality, hence HHSK was not involved by due to association with any regulations. Engineering consultancy Tauw did not have an interest in the mainstreaming of the innovation. However, they did have a lot of knowledge concerning the appliance of SuDS and thus helped in the mainstreaming of the process (Interviewee 9 & 10).
This stakeholder analysis based on documentation was cross-checked with interviewees from within the project, they have further highlighted the important stakeholders within the case that would be interesting for interviews. These stakeholders were from within the Municipality, Bufferblock B.V., and engineering consultancy Tauw B.V.

6.3. ORGANOGRAM AND DECISION MAKING PROCEDURE

The organogram of Capelle has been displayed in Figure 6.3, similarly to the municipality of Rotterdam it is divided into policy determination- and execution segments. The same procedure described under Section 5.3 to the allocation of budgeting by the board and approval by the council is applicable.

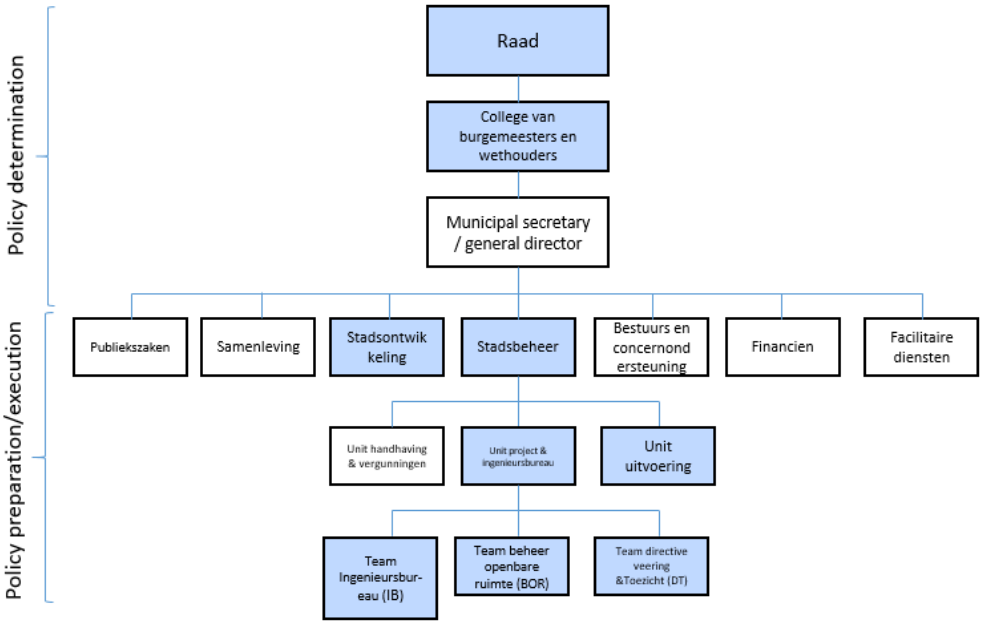

Figure 6.3: Organogram of Capelle a/d IJssel adapted from Gemeente Capelle (2017).

Two different clusters are involved which are named identically to those in Rotterdam: Stadsontwikkeling and Stadsbeheer. In this case, both the formulation of assignments and execution are carried out entirely by Stadsbeheer. Stadsbeheer in Capelle does not purchase supplies, this is carried out by the contractor. Within Stadsbeheer there are different units. The unit Project and engineering consultancy consists of three teams, of which the BOR (Asset management) and IB (Engineering consultancy) are respectively involved in providing assignments and translating this to practice (Interviewee 9 & 10). Team BOR is the managing team that is responsible for the constructions that are in place and consists of multiple disciplines, they provide inspections and maintenance. When new assignments follow from inspections they assign those to the team IB (Interviewee 9). Per discipline, there is usually one senior employee present in the project teams (interviewee 10). The DT team is involved in obtaining permits, and supervision during the execution phase together with the unit concerned with project execution.

"Besides I do have the obligation or task, which is normal, that if I can provide advice ... I make a notion and provide this to team BOR ... it's up to them what they do with it. " - Interviewee 9

The cluster of stadsontwikkeling is focused on the development of the city. They develop new policies and are responsible for spatial development planning. Within their cluster there is a specific

unit that governs the finances, through this unit the grant of the Star2C project was retrieved. Lastly, the executive board and council are involved in granting permission for projects that are not incorporated in the program budgets.

6.4. THE MAINSTREAMING PROCESS DESCRIPTION

In this section, the analysis of the first iteration of the mainstreaming cycle (Figure 3.1) for the Bufferblock is elaborated, according to the methodology presented in Chapter 3. The mainstreaming framework is thus applied specifically to the implementation of the Bufferblock through the WaterWeg project in the municipality of Capelle. For the full overview of codes corresponding to the interviews refer to Appendix **G**.

6.4.1. DRIVERS - STATUS QUO POLICIES

Similar to Rotterdam, Capelle was affected by the North-Sea Flood of 1953. To provide protection against the sea, a flood control structure was built on the IJssel River right on the boundary between Capelle and Krimpen. However, this dates back to half a century ago. Since then, no concrete initiatives, policies, or strategies for innovative climate adaptive solutions have been formed that were applicable to this project (Interviewee 9 & 10).

The main policy applicable to the project was the MSP for the period of 2016 - 2020. The MSP specifies five different goals:

1. Socially justified sewer management
2. Responsibility for collection of waste water
3. Responsibility for processing rainwater as consequence of rainfall
4. Contribution to maintaining surface water quality
5. Responsibility for the groundwater regime

Concerning rainwater, the responsibility is focused on the prevention of pluvial flooding. The municipality did not have major issues concerning rainfall, not from practice or by theoretical calculations (Gemeente Capelle, 2015). The MSP states that calculations were planned for new insights that regarding climate change during the MSP's applicable period. It was explicitly mentioned that these insights would be beneficial regarding the spilling of combined sewer systems on surface water. Measures in the MSP read calculations for sewer systems by adding in a safety factor of 10% on standard precipitation values or acceptance of water on the streets.

The document states that pollution of the surface waters has decreased due to creating distinctive sewer systems for the rainwater (Gemeente Capelle, 2015). For the installation of new pipes, disadvantages are named in terms of costs, maintenance, and the limited amount of space underground. A slight preference for a combined sewer system is therefore mentioned in the MSP, which implies maintaining the spilling frequency on surface waters when no intervention takes place.
As the municipality camps with high ground water levels and consolidation, the sewer system subsides unevenly. It is possible for groundwater to infiltrate through tears and open joints into the sewer system. This decreases the amount of storage and drainage capacity of the system. The amount of water that infiltrates the sewer system is estimated to be approximately 30 - 70% of what is delivered to the treatment facility. Furthermore, the lifespan of sewer systems in the municipality is mostly expected to be around 30 years instead of 40 - 45 years as a consequence (Gemeente Capelle, 2015). In the MSP the lack of ground water trouble is partly attributed to the passive drainage through the sewer system, even though the municipality does not take major large-scaled drainage solutions. Minor measures that have been named are the application of drainage tubes.

In conclusion, an integral approach that takes surface water quality and groundwater levels into consideration has been promoted (Gemeente Capelle, 2015).
A coalition agreement was signed for the years 2018 - 2022, which names the preparation against extreme rainfall again. In this agreement two different criteria were specified:

- A sustainability agenda will be drafted
- The proposal of a local sustainability fund will be executed within financial limitations

Later in the earlier phase of the project, early 2019, the sustainability programme was formulated. The agenda is split up into three different themes: circularity, energy and climate adaptation. The WaterWeg was mentioned and the motives for the project were mentioned as the experience gained by application of new materials and knowledge concerning the costs and effects. The budget specification indicates that most of the budget in the strategy is allocated towards the energy transition, rather than climate adaptation. On yearly basis, a budget has been established of €50.000. However, the budget is mostly allocated to creation of awareness amongst citizens, companies etc. This leaves little margin for pilot projects.
The agenda did contain the plan for a stress test, which would indicate risks about drought, heat, fluvial-, and pluvial flooding. This stress test was outsourced to Nelen and Schuurmans and provided the municipality with a map of bottlenecks and opportunities concerning water and climate adaptation (Nelen en Schuurmans, 2019). The produced maps based on the stress test indicate that no significant water issues were applicable to the project's location, this was acknowledged in an earlier meeting (Gemeente Capelle , 2018).

"How did we select the neighbourhood? ... Every 20 - 25 years you will find that the a specific neighborhood has to be serviced" - Interviewee 10

This has to do with the execution agenda for replacement and renovations of outdoor space, which is made every 4 years. For 2016 - 2020 the neighborhood of the Arica was put on the agenda (Interviewee 10). Initially, the renovation and maintenance would take place using traditional practices. However, a colleague from stadsontwikkeling managed to obtain a grant through the Star2C project.

"We have a colleague that is engaged in the obtaining of grants ... Normal grants from the national government, provinces and other organizations... He has experience in politics, so he has access to a certain network" ... This colleague was indirectly the initiator of the project through one of his networks spanning across Europe. However, he didn't have any further input in the project. When he received the option for the grant, how we would apply it was the question." - (Interviewee 10)

This grant was considered the main driver of the renovation of the Arica (Interviewee 9 & 10). The Star2C funding had a time constraint, which was aligned perfectly with the renovation that had to take place in the Arica. This was line of though that led to the choice of the neighborhood.

6.4.2. INITIATION PHASE

In this section the initiation phase is elaborated, it consists of the understanding, willingness, and enabling sub-phases. It differs from the drivers section as it analyzes the receptivity and boundary spanning theory on a practical level rather than an organizational level.

UNDERSTANDING

To the question, if there was any prior experience with SuDS in the past the following was stated:

"To a certain extent. We do not only implement sewer systems with rubble and sand ... No, of course we look further ... We have applied lava-stone and other solutions for elevating of the surface levels" - Interviewee 9

No, not really .. WADIs were not present too, the only experience we had involved light filling materials - Interviewee 10

The practitioner's were aware of their boundary conditions, which are shaped by their consolidation and higher ground water levels. Light filling materials such as BIMS, Repac, and other light filling materials have been applied (Interviewee 9 & 10). An additional advantage is that these products have a high porosity, which allows for water storage and delayed drainage.

Thus, indirectly there was knowledge about SuDS however not necessarily for the purpose of draining water, but rather for the elevation of the ground levels.
Support for the idea of SuDS was found to be present in a small group of colleagues within the IB. Naturally, if it is not suggested by the BOR anyways it would not be implemented, as the IB has to finish their own assignments (Interviewee 10). However, as it as mostly unknown, it was not desired at the BOR. Within the department of BOR, the urgency was also not necessarily attested, this resulted in no initiation (Interviewee 9). Previously, it was perceived harder to persuade colleagues and the board of innovative solutions. However, now that the grant was available this became the driver that made things possible.

"We could do it, without it hurting as much financially. The extra costs of the measures were covered by the grant" - Interviewee 10

As stated in section 6.3, the IB and BOR are subdivided into different departments. However, as the organization is rather small it was easy to find the internal actors for assembling a project team (Interviewee 9). The internal project team consisted of :

- BOR - Project manager greenery
- IB - Project manager water management
- IB - Three Planners
- DIT - Supervisor

Within the execution only one colleague with expertise in the watermanagement field was available. According to interviewee 9, different colleagues had to be persuaded to give a practical meaning to the grant. The first one was the asset manager concerned with maintenance of the paved area.

"There are certain routines in place, the application of a new pavement material was very thrilling ... With many conversations and convincing power we have persuaded the specific colleague that it does bring added value" - Interviewee 9

This mostly relates to reliability of the initiating colleague and communication skills. As far as boundaries had to be pushed within the municipality, the most important key-agents of change involved in this process were the two project managers from the IB and BOR. These were colleagues with senior positions, which had built a lot of credibility in their careers (Interviewee 10). The other colleagues that had to be convinced for the application of the grant were the members of the council and executive board.

"With our enthusiasm, we had to persuade the council that we could involve the citizens at a more intensive level .. people saw more problems than chances " - Interviewee 10

Important notions were that the grant could be used for theoretical research rather than putting it in practice and coupling it with a renovation project. Furthermore, the persuading of the citizens has been deemed an issue as it would take place in their neighborhoods.

"There was an awareness that we could learn from this project by the IB and BOR ... Eventually, even the aldermen had the feeling that Capelle could be put on the map" - Interviewee 9

In essence, it boiled down to telling the full story. Capelle is situated next to the IJssel and protected by the Dike. The pumping station has to overcome a significant elevation, for which a large amount of water is pumped into the IJssel. It was preached that a large amount of this water could be re-used by replenishing the groundwater levels. The subsurface consists of peat, when peat dries out the consolidation increases. This narrative persuaded the local politics, given the clarity and marketable content (Interviewee 9).
In addition, the adaptation Catalogue by Deltares was utilized by this time as well. It was used to help management in making decisions regarding climate adaptive measures. The tool could indicate that a larger investment now would have a higher yield in the long-term. Furthermore, the nuisance for citizens would be less frequent, is what was concluded by the Deltares report (Interviewee 9).

"The grant after all was not that significant ... However, it created enthusiasm amongst the higher ups.". - Interviewee 10

The grant turned out to be around 20% of the project budget (Interviewee 10). Due to extra budget being cleared for the project by the council, the extra costs of the project were fully covered.

ENABLING & PLANNING

As consensus was reached amongst the internal stakeholders by now, the planning of the project could be made concrete. The permits required for this innovation were rather standard according to interviewee 9. Within this phase, new parties were involved, including the citizens, HHSK, Tauw, and Bufferblock (See table 6.1).

"We're all creative and enthusiastic, but in the factual elaboration and design of the project we required the cooperation with Tauw" - Interviewee 9

The applicable innovations were explored and chosen by the municipality itself, for this their own team has visited other municipalities and the Greenvillage (Interviewee 9, 10 & 11). They created an initial selection of relevant products to their boundary conditions. Parallel to this process, a gathering with the citizens was organized of which the presence was around half of those whom it may have concerned. The goal of this meeting was to have a representative board of the citizens. This group was responsible for bridging the thoughts of citizens to them municipality and contrariwise. It was found that the citizen effort was high in the beginning, but diminished eventually intended representative group was to be formed. It is to be told that the project managers from the municipality were pleasantly surprised at how the citizens were thinking along in the upgrading of their neighborhood after this session. It came forward that as the project was rather large, that the accessibility of neighborhood should not be impacted minimally. Thus the smaller renovations had to be scheduled in an organized manner. A time constraint also followed from the citizens in terms of the duration of the project, as well as from the grant which assigned a deadline to the project.

Soon after the citizen's meeting, the external engineering consultancy Tauw B.V. became involved. Their cooperation was mainly focused on the building of the product than working on the cooperation as this went smoothly (Interviewee 9 & 10). Factors that shaped this positive cooperation cooperation were factors of openness, eagerness to learn, and acknowledgment of their limitations where a team member required help. Tauw was involved as the municipality had a lack of knowledge concerning calculations and designs with innovative products (Interviewee 9 & 10). The first step they did while working closely with the municipality was creating an MCA for the proposed solutions by the BOR. The options that were taken into consideration were mostly interventions at the surface level which were all deemed technically feasible.
The MCA took into consideration the following factors:

- Climate resilience
- Sustainability
- Future proof
- Feasibility
- Maintenance scoring
- Citizen scoring

The highest weights were attributed to the climate resilience, future proof and maintenance scoring. For the resilience, the type of solution was ought to score well on being a resilient solution in terms of rainwater and groundwater. For being future proof, the most important criterion was the indication of to what extent the product could be applied further in the municipality. By the maintenance unit the first criterion was how it fit into the maintenance norms and standards. But more important was how the innovations scored on the costs of implementation, and of short- and long term maintenance costs. Additionally, the durability of the construction was found to be a a major factor.

From the MCA conducted by Tauw and the municipality, it followed that Bufferblocks, Wadis, and permeable were the most interesting for the neighborhood (Gemeente Capelle, 2019).

For the specific innovation itself, there was a possibility of combining it with porous pavement or permeable pavement. The municipality made it clear that they didn't opt for permeable pavement as it involved a ZOAB cleaner after clogging would form within a few years and that was something they were not willing to do (Interviewee 9). A decision was made from the maintenance perspective that they would rather have constructions that are easier to manage and are more robust. Therefore, it was opted to transport rainwater into the Bufferblocks with gullies.
As Bufferblocks is a rather straightforward solution in terms of concept and space, the consultancy only had to make sure it could be integrated into the surroundings and underground (Interviewee 11 & 12). The technical specifications were communicated by the Bufferblock to Tauw, which eventually processed this into engineering drawings to make it practical (Interviewee 11).
As the municipality still deems the construction a pilot, the Bufferblocks have been connected to the sewer system that was in place. Hence, when the system is full and can't drain towards the ground, there is still a spillway on the surface water. The end product of this phase was a final project plan, including a maintenance & monitoring plan for the constructions.

6.4.3. MANAGING

EXECUTION

During this phase, the supervision was fully done by the IB's project manager. For the execution earlier permission was granted from the Network operator, to place the Bufferblocks at the determined location.

When the Bufferblocks arrived and confirmation was asked, different those that were responsible for the utilities revoked their permission.

"During the execution, we had to divert the gas conduit or drinking-water piping so that these were not situated under the Bufferblocks" - Interviewee 10

The network operator is in fact part of the municipality, however, their reconsideration was formed due to not having the willingness of having the home connections to the gas network under the Bufferblocks. The only system that remained under the Bufferblocks was the in-situ sewer system, this was in agreement with the sewer operator. Furthermore, the placement of the Bufferblocks had no implications and everything went as planned. One notion mentioned was that the crane used for the Bufferblocks could be altered so that it could grab more of them at the same time (Interviewee 10 & 11).

MONITORING & MAINTENANCE

The monitoring was already planned by Tauw before the implementation took place and was established in their monitoring documentation (Tauw, 2019).
The monitoring of the system has been divided into different themes: 1) consolidation and 2) the increasing of the water storage and delayed drainage.
For the consolidation it was expected that the Bufferblock would be lowered, than with regular foundations. Hence, five measuring locations were chosen for which monitoring takes place through data loggers. A report would be released every year that reports the trends within the measurements.
The monitoring of the pure delay in drainage was expected to be minimal and difficult to measure. Hence, the second theme was mostly evaluated by measuring the storage (Tauw, 2019). Different measuring locations have been indicated for the water level within the Bufferblocks, for this different level indicators have been installed which contain dataloggers. Similarly to the consolidation, annualy a report will be created concerning these measurements which log the water levels in the bufferblock (level indicator, date/time, and the hydraulic head m Nap).

"We are looking at the moment for how to maintain these things .. It is now situated in the public space but how do you maintain it? - Interviewee 9

"The maintenance is not really known for us at the moment, we are the first that have implemented this solution" - Interviewee 10

The maintenance has not been established yet, it became evident that the municipality conceived this implementation as a pilot to test the waters. However, large questions concerning the Bufferblocks or sewer system under it have not been proposed yet (Interviewee 10). The maintenance as of now is done by the sewer manager, who treats it just like another gully that will have to be inspected every year. In addition, it is mentioned by Interviewee 11 that maintenance can take place through sewer inspection with CCTV pipe inspection hardware and by flushing the blocks with a high-pressure cleaner. He acknowledges that until now this was not required as the system functions properly, a notion was also given that maintenance usually takes place once every 5 years according to maintenance periods of crates. Interviewee 9 & 10 further stated that it is expected that things concerning maintenance will still have to occur. However, the spaces between the spaces of the Bufferblocks are larger than pore size hence the ancitipated clogging will take a while to occur. In the short term, they want to start with load testing to research the impact of heavily loaded vehicles braking on the Bufferblocks (Interviewee 10). Thus far, the water in the Bufferblocks has been draining rather

quickly to the underground and no reason for more intensive maintenance has been established, hence no additional costs were anticipated.

EVALUATION

Two important factors were brought forward by both interviewee 9 & 10 for the implementation process, which were the costs and boundary spanning capacities of those involved. Both of the project managers agreed that without the subsidy by STAR2C the project would not have taken place and the renovation would have taken place traditionally.

"People will not admit this easily, but this is true ... I mean, it is not often directly spoken of ... I think it would have been the same case for us, if we did not have the subsidy we would most likely just follow our regular program concerning maintenance, which would mean it wouldn't even be featured" - Interviewee 10

"No, the subsidy was the real trigger for the project" - Interviewee 9

Interesting in this case is that the subsidy was available before a concrete project was established. The receiving of a grant after selecting a project may cause a delay in the project due to the application process being rather slow. When asking for what could be another driver that could start this project, real urgency was named.

"Years of majordamage due to heavy rainfall I could think off, real urgency" - Interviewee 9

The project itself has sparked an interest within the municipality to implementation of SuDS a part of the climate adaption becoming more important, it is now deemed a viable option that can be taken into consideration more often (Interviewee 9). Key-agents of change were deemed rather important in this case, as this has lead to the program of outdoor space is being re-designed. Even politicians were involved, there is a positive discourse for anchoring climate adaptation into policies (Interviewee 9). This is seen in the sustainability agenda, which structurally reserves €50.000 for the topic during the years of 2019 - 2022. The program shows that the energy transition and climate adaptation budgets are competing with each other. As the anticipated budgets are significantly higher than what is available, requests will have to be done at the council every year.
The up-scaling potential was anticipated to be larger in the long-term without requiring subsidy from a third party, as the innovation will have had the time to prove itself by then. The municipality has promoted this solution widely through: pitching it at the Star2C conference, media coverage, and inviting other municipalities. Furthermore, informational videos about the technology have been placed on the website of Bufferblock and Climatescan. The reports of the monitoring have not yet been published.

For the short-term the answers are a little more complicated within Capelle. Conversations have taking place about the short-term upscaling potential of the technologies on the WaterWeg. The most prominent least intensive solution is the use of water passing pavement and parking spots, these are easy solutions to implement that require almost no additional measures. The Bufferblock has simply not been considered yet as it larger intervention that requires more information on its functioning on the long-term. The solution also seemed more cost-intensive when comparing them to conventional solutions. Which comes back to the budgets of the municipality, which are becoming more strained as decentralisation of autonomous tasks is occurring from the central government to

municipalities.

"However, the question then remains if it fits the budget or needs to free up more budget ... Another question is where do we get this budget from? ... There are municipalities that want to strike since they have to accept the Jeugdzorg as well ... Capelle has to budget 5 million euro's ..." - Interviewee 10

Without a subsidy, it is questionable if they will be implemented again within a brief time span (Interviewee 10). From another perspective, the startup mentions that due to the recent developments on a national scale, it should become easier for municipalities to adapt (Interviewee 11). Contrarily, subsidies such as Star2C and TKI are meant for gathering knowledge. Once the pilot phase of an innovation has passed, it does lose it's privilege on the incentive of what subsidies are meant for. This leads to the notion that mainstreaming an innovation like the Bufferblock in the short-term due may be tough.

On a technical level, the Bufferblock was found to fit this municipality rather well due to the boundary conditions.
When up-scaling it is deemed interesting to look into municipalities that have similar boundary conditions, for which interviewee 11 added that it is beneficial to also analyze options abroad as well.

"Basically we are focused on the larger cities in the Netherlands, with a high percentage of paved area, dense population, and less greenery is present ... Combining this with area's that have a high Groundwater level, these are the area's of relevance to our company" - Interviewee 11

On the contrary, the cities and towns where the next implementation would take place were mid-sized. One argument named for this is that from their experience with Capelle, communication with smaller municipalities makes the communication and process smoother and easier (Interviewee 11). In addition, the company is looking into solutions which span abroad, while also trying to improve re-using water within the system.
Furthermore, the innovative character of this innovation was as stated by interviewee 10, not revolutionary. In the sense that rather than functioning as an optimized system, it was straightforward. This brings along less risk than an innovation that also accommodates treatment and re-use of the water. The maintenance of this innovation was thought of to be rather straight forward too. Thus overall, the technology of the system was rather predictable. Even though monitoring is still going on, this is likely one of the reasons why different municipalities have now implemented the Bufferblocks as well.

6.5. KEY POINTS OF CHAPTER

A summary of the identified factors and whether they function as drivers or barriers has been placed in Table 6.2.

	Drivers	Barriers
Drivers	- The availability of the Star2C grant - The policies indicate a large knowledge base on the current sewer system and issues - There is a sustainability agenda that creates budget for climate adaptation (Awareness) - The stress-test indicates areas where water issues may occur. - The project managers took the roles of key-agents upon themselves and portrayed qualities of long-term vision, persuasion and trust.	- There were no policies, strategies or other policies available that projected intentions regarding SUDS. -Financial limitations, this causes the decision making process to be partially political. These are amplified by: - Decentralization of tasks by government to municipalities - No specified budget for innovations. The energy transition competes with transition agenda.
Initiation	- The knowledge of their own capabilities enabled an initial selection of possible technologies - The municipality was easy to interact with as the project team was rather small. – The assignment came from the maintenance unit, for which only one expert was involved regarding UWM at the IB. - Not revolutionary technique, hence easier to maintain.	- Discourse concerning permeable pavement - Routines concerning the execution of maintenance were in place, which led to no introduction of new innovations. - There was limited knowledge concerning SUDS and no practical experience. Hence external expertise was required. - The maintenance unit had to be persuaded of the benefits
Planning	- Availability of large renovation project which gave purpose to the grant. - The project team did have trust in each other's capabilities. The cooperation was oriented at the final result. - The citizens were actively involved	- The network operator was uncomfortable with the innovation, hence the underlying piping system had to be redirected
Managing	- Awareness has been spread widely internally and externally. - The municipality in general is now more aware of innovative possibilities and more willing to take these opportunities. - Through media presence and conferences the technology has been promoted.	- No maintenance routine has been concretely established - No documents concerning the performance or maintenance have been published publicly

Table 6.2: Summary of the drivers and barriers in the UWB project

7

COMPARATIVE ANALYSIS AND FOCUS GROUP

In the previous chapters two case studies have been performed, this chapter aims to gain insights into differences and similarities between the identified factors. As a second step, the focus group results have been presented in which the comparative analysis has been discussed. The focus group has been scheduled for gaining insights into the generalizability of findings by the case studies. An overview has been provided

7.1. COMPARATIVE ANALYSIS

7.1.1. DRIVERS

POLITICAL SITUATION

The majority of the council in Capelle is formed by Leefbaar Capelle, which is a political party that strives for the liveability of the citizens. In their election manifesto, climate adaptation has been mentioned. The coalition agreement in 2018 did mention the formulation of the sustainability agenda, however, no further information was provided. Additionally, since this coalition, they have an Alderman for sustainability. For Rotterdam, the political situation and their latest coalition agreement had marginal impact on climate adaptation in the municipality, since their council has been supportive of climate adaptation for decades. Besides the political situation, the city of Rotterdam is leading in the field of climate adaptation, and actively pursues this image.

NATIONAL POLITICAL ATTENTION & LOCAL POLITICAL ATTENTION

The DPRA is a policy that provides guidelines for spatial adaptation in local governments (i.e. waterboards, provinces, and municipalities) to be more climate-adaptive by 2050. For all municipalities, an obligation and guidelines are formed to become more climate-adaptive by the creation of a sustainability strategy. Furthermore, the Impuls Regulation enables municipalities to gain grants for the implementation of pilots and the development of knowledge.

Both municipalities have established long-term strategies for 2050 concerning climate adaptation on the public level. In the municipality of Rotterdam, this strategy has been expanded since WP1. Their reliance on supportive policies by external government bodies was found to be low. In Capelle, the sustainability agenda has been drafted as a follow-up on the DPRA and the political attention.

The latest strategy of Rotterdam, Rotterdams Weerwoord, has been integrated into their MSP. This is a strategy that has been primarily focused on climate change and water. Their objective is to start scaling up as they aim to be climate-adaptive by 2025 and to stay relevant as the pioneer. Hence, upscaling and further exploration of innovative ideas are highly prioritized in the short term.

In Capelle, even though they have the same boundary conditions, the water issues were appeared to be not as prominent in their policies. Their climate-adaptive ambitions are named in the sustainability agenda that also covers the energy transition and circularity. Their ambition reads: "to gain insights in climate change in Capelle, and to take concrete steps in the creation of awareness". The priorities of the sustainability agenda fixated on the energy transition, as this part seems more promising in terms of ambitions, budget, and concrete goals. Additionally, a stress test has been conducted which indicates areas that require extra attention. The anchoring of these projects into destination plans and a strategy the anchoring remains yet to be one, but could help flesh out their overall plan.

BUDGET AVAILABILITY

In the municipality of Rotterdam, a significant budget is allocated through the MSP. The total amount on annual basis for sewer management is approximately €31 million. The budget is based on the sewer management taxes[1], which increases with the together with the amount of citizens. Part of the climate adaptive procedures is funded by the MSP. On annual basis, a budget of €175.000 is cleared for the development of knowledge, and an additional €500.000 is specified for research and planning. In the case study, it came forward that the total expenses for the municipality were approximately €800.000. The municipality thus has a large number of expenses they can cover regarding climate-adaptive procedures that are associated with the sewer system.

In Capelle, the total budget specified in the MSP is approximately €4.8 million for the year 2020, for which a shortage of €300.000 was predicted. Structurally, €50.000 is allocated to climate adaptation and research. But this is essentially reserved for the creation of awareness in the coming years. For both projects, the grants formed a small fraction of each project's total costs. However, the availability of grants was perceived to be an ultimately decisive factor for both cases according to the interviewees. Decentralization of tasks (e.g. Jeugdzorg[2]) by the central governments to the municipalities has caused shifts in the budgets. This imposes an additional restriction for extracurricular activities concerning SuDS are therefore further limited. Accordingly, Rotterdam does have a larger range for exploration in terms of available expenses.

AVAILABILITY OF INFORMATION

The organization of Rotterdam has its own engineering consultancy. Different specializations were involved in the process (e.g. geohydrologist, climate adaptation specialist, urban water manager). In the case of Capelle, only one specialist was involved. The innovation in Rotterdam was technically more difficult, hence the lack of expertise required outsourcing to external consultancies. Regarding the implementation of normal SuDS, it was mentioned that the municipality has enough knowledge to facilitate this on its own. This knowledge was found to be spread through informal means such as presentations by project managers and the use of Intranet.

Differently, civil engineers are working at the consultancy of Capelle which had no knowledge of

[1] in Dutch: Rioolheffing
[2] Youth services

SuDS. For the establishing of the project, only one internal expert with a civil engineering background was part of the project team. Therefore, additional help was required by the external consultancy to perform calculations and design the monitoring plan. The knowledge dissemination of innovations was mostly done incidentally through informal collegial conversations.

CHOICE OF INNOVATION

The choice of the innovations in the case of Capelle took place with the use of an MCA, opposed to Rotterdam where the innovation choice was set from the beginning. An initial selection of technologies took place based on the boundary conditions, technical feasibility, and financial viability deemed by the municipality. A climate-adaptive catalog was used to further endorse the choices. The considered techniques mainly intervened at the surface level, of which most had some proof of functioning or resembled current practices.

The latter came forward as there was a discourse was mentioned towards permeable pavement, as this didn't fit the standards of the maintenance. The most relevant factors in the MCA were the initial investment costs and maintenance costs. Furthermore, the longevity and upscaling potential within the municipality were listed as highly valued. The technique applied in Rotterdam was completely new as it was circular, and required additional modeling to evaluate the impacts of implementation. Furthermore, the solution was found to be relatively expensive when compared to to the solution in Capelle.

THE DECISION-MAKING PROCESS

In both cases mainly two parties were involved, asset management and the engineering consultancy. The assignments in both cases were provided by asset management, which are deemed the end-users. They are responsible for the inspections and maintenance of sewerage facilities and paved areas. As asset managers are responsible for the infrastructure after implementation, they are deemed as the end-users. Hence, they specify the available budgets. In Rotterdam, permission was granted by the head of the unit of asset management.

In Capelle, the specified budgets in the annual budget estimates of asset management were exceeded. Which therefore required permission for additional budgets by the council. Specifically, as groundwater infiltration took place in the case of Rotterdam, permits had to be obtained by the Waterboard. However, the obtaining of permits in both cases didn't seem to be a large factor.

WILLINGNESS

The opposition formed in Rotterdam at the consultancy was found to be based on two notions:

- Formation of optimized routines due to doing projects in the same manner repetitively
- The dilemma of acting now or later for coping with climate change

In Capelle, these routines were also in place, but never broken due to the workers being too occupied with their daily tasks. As such, there was no incentive to break out of their routines until the Arica had started.

The asset management units in both municipalities were hesitant as there was a lack of knowledge and concern about the use of the construction given the maintenance of the innovation and other sub-surface infrastructure. Additionally, for landscape architects the integration in the surroundings was important.

REQUIREMENT KEY-AGENTS OF CHANGE

In both municipalities, the knowledge and support for SuDS have been limited to a specific group at the engineering consultancies. In Rotterdam, these are the pioneers that are responsible for the projects surrounding most innovations. These practitioners are mostly present within engineering consultancies and spatial development. The initiator within this group was required to push boundaries within the organization to build a team around the innovation. Characteristics of this individual were: perseverance, trust, knowledge, network, long-term vision, and convincing power. In Capelle, this was found to be similar. The colleague that obtained the grant, in this case, persuaded his other colleagues to use this grant for a practical project. Perseverance, trust, and persuasiveness were mainly important here. There was no long-term vision yet, although this has been established during the project as it became anchored into the sustainability strategy.

7.1.2. MANAGING

IMPORTANCE OF ESTABLISHING PROPER MONITORING AND MAINTENANCE

Both municipalities have taken into consideration the monitoring of the performance of the innovations. Measuring the functioning of both constructions has been concretely established in planning, on annual basis reports are produced. A difference was found in the maintenance, which has been established in Rotterdam. However, in Capelle, the interview participants stated that there was no concrete maintenance routine. Given the simplicity of the innovation, suggestions for maintenance were cleaning through high-pressure cleaning as done in manholes.

SPREADING OF KNOWLEDGE OF INNOVATION

The first implementation is a good start, however, the fact remains that a single measurement is no measurement. Hence, for building more proof of functioning, more knowledge is required. The WaterWeg has been mostly promoted through the Star2C conference, media attention and multiple municipalities have made their interests in the project known. In Rotterdam, additional reports have been released by the project team. These reports concern a CBA, technical specifications, monitoring results, and maintenance. These types of documentation can support the proof of functioning and benefits of the innovation. The spreading of this knowledge has been favorable for the innovations as new implementations have taken place.

SUMMARIZING TABLE CASE STUDIES

The comparison of the case studies has been displayed in Table 7.1 on the next page.

	Main similarities	Main differences
Drivers		- Adaptation strategy with intermediate goals has been established in Rotterdam. These goals have to yet be established in Capelle which will form a major driver. - Dependence on national policies was found in Capelle for kick-starting the climate adaptive policies - Rotterdam presents itself as a sustainable city
Initiation	- Inertia: - Optimization of routines - Lack of short-term interest in climate change - Requirement of initiator and boundary pushers for creating deep support - Opposition was voiced by the asset management concerning sub-surface, fitting into the environment, performance, and maintenance. - Subsidies are deemed important in both municipalities. The project budget was smaller in Capelle, this could imply a higher dependence. - Requirement of external expertise - Based on knowledge - Based on capacity	- The municipality of Capelle was mostly unaware of SUDS before the project - Active information sharing has to take place in Rotterdam concerning SUDS, internal awareness is created with less effort in Capelle. - The budgets for experimentation and knowledge expansion Rotterdam are significantly larger than in Capelle and specified in the MSP. - Amount of colleagues required to inform is less in Capelle, the process is less rigid. - The permission for the project is a political decision in Capelle rather than on practitioner's level as in Rotterdam - The choice of innovations is made more carefully regarding the budget and technical feasibility in Capelle.
Planning	- Involvement of citizens - Availability of linking the project to a destination plan (work with work) concerning maintenance or water issues - Trust in capabilities of project team - Discourses were in place regarding certain technologies	
Evaluation	- Active spreading of awareness was planned through conferences and media presence. - SUDS are mostly still in an experimental phase, those that have not been widely implemented will require time for evaluation - Implementation at other locations has taken place	- Technical drawings, maintenance- and monitoring procedures, and a CBA have been distributed by UWB team. - Lack of maintenance strategy in Capelle

Table 7.1: Comparison of factors retrieved through case studies

7.2. FOCUS GROUP RESULTS

The results of the comparative analysis were discussed in a focus group. In total four different municipalities participated in the session. The conversation included their experiences over the current coalition session (2018-2022). The focus group was carried out online, through a Teams meeting in October 2021. The participating municipalities and their characteristics are listed in this section4.5. The objective of the focus group was to obtain an impression of how other municipalities relate to the findings of the case studies. The main factors as concluded from the case studies were discussed in the focus group, and the findings have been presented in this section. As there were time limitations, these main factors were limited to: Policies, Decision-making at the practitioner's level, and up-scaling. Project-specific things that were found to be different were left out. For a brief overview please refer to Table 7.2

AVAILABILITY OF STIMULATING POLICIES AND STRATEGIES

The case studies indicated that the strategy has been far more substantiated in the policies of Rotterdam. The mid-sized municipalities mentioned that their climate-adaptive visions had been drafted according to the DPRA (Participants P & R). Similarly to Capelle, ambitions for climate adaptation have been established in those municipalities. However, the strategy to reach these goals has not been established yet. In the larger municipalities, all the steps of the DPRA have been followed as well, before the current coalitions there were no formal procedures. Their strategies are not only based on their climate-adaptive policies but span across practitioner's levels as well. Policies concerning climate adaptation have concretely been stimulated by the DPRA, which is different from the findings in Rotterdam. Two different strategies are being used in the larger municipalities which facilitate innovative approaches:

- Using the additional boundary condition of climate change in the program of requirements for spatial projects (Participant A)
- A guideline for first referring to the stress-test before the program of requirements (Participant S)

The strategies in the larger municipalities offer a more structural approach for integrating climate change into the practitioner's level. It does not form a guarantee, but may create more awareness on the topic.

BUDGET AVAILABILITY

In all municipalities budgets were (indirectly) allocated to climate change. However, these were not necessarily meant for experimental measures or SuDS. In the mid-sized municipalities, signals are given by the asset managers that the current budgets are not enough for incorporating climate adaptive measures. For which in one municipality a request is done for the raising of the sewer taxes, in the other municipality this has already been done.

"The council is never fond of requests for more budget after the annual budget estimates have been established … Hence, we have raised the sewer taxes by 10%, which will hopefully be sufficient for covering additional practical measures" – Participant P

"Till recently we didn't have to get our budgets from different programs since we have established this in our policies this is no longer necessary … This has happened very recently" – Participant S

It was found to be important that budgets specified in the MSP should be linked to interventions that contribute to groundwater level maintenance and buffering of rainwater, rather than the sewer

system only. The budgets in the larger municipalities have been concretely established in the MSP, and explicitly funds have been allocated towards climate change and innovative procedures. However, the allocations of the budgets have only been established within the last few years as opposed to Rotterdam.

All participants mentioned that their municipalities have signed up for the Impuls Regulation (IR) as part of the DPRA. This is a regulation that is only linked to practical interventions as a consequence of the stress tests. The IR enables all municipalities to fast-track their climate adaptive measures for the areas of interest indicated by the stress test. Lastly, only one mid-sized municipality has named that the sustainability transition has been coordinated by a team that has to divide their attention amongst different topics. The energy transition has received great attention, at the expense of climate adaptation.

AVAILABILITY EXPERTS AND KNOWLEDGE OF SUDS

The number of available people with a civil engineering background was limited in the mid-sized municipalities.

"The only person involved in the separation of sewers is the sewer manager. He is actively involved, then you've had it. We have no advisor for the underground. For cables and pipes, we do normally have a consultant" – participant P

The larger municipalities also mention that they have fully developed engineering and development clusters, which encompass hundreds of people. Overall, municipalities specified that external expertise was dependent on the nature of the innovation and the capacity in terms of available workers. Furthermore, it was found that SuDS has been applied before the coalition agreement in most municipalities. Only participant P, mentions that they have recently started experimentation with innovations. Due to the stress tests that have been conducted in each municipality, the areas of interest are now well known.

CHOICE OF INNOVATION

Large renovations are usually scheduled a year ahead, for which specific project budgets are established upfront in the annual budget estimates of the specific coherent program. The innovation choices were among other factors decided by the available budget. The size of the projects varied amongst the municipalities regarding their budgets and spatial availability, however, they were all convinced that the choice of innovations was relevant for their boundary conditions and mostly linked to other projects which formulated the requirements (e.g. renovations and new buildings). The aspect of pioneering by implementing an innovation for the first time did not seem to be prevalent, nor were they found to be limited to the front running municipalities.

"Our projects are smaller than in a G4 municipality, but we can still be an example for larger municipalities and citizens" – Participant P

The mid-sized municipalities are predominantly occupied with the first generation of SuDS. The re-use of water has only been initiated in one larger municipality.

THE DECISION-MAKING PROCESS

In all municipalities it was found that the decision-making process spanned amongst three groups: 1) the engineers/developers, 2) the asset managers, and 3) the council. The asset managers specify

the assignments first group. The higher-ups seemed to be of relevance in the mid-sized municipalities. When the budgets are exceeded which seemed to be the case in the mid-sized municipalities, the alderman or council have to be persuaded for allocating extra budget (Participant P).

WILLINGNESS ON PRACTITIONER'S LEVEL

The requirement of initiators was a common concept in all municipalities, on an organizational scale from a policy perspective indications can be provided to the practitioners. The municipalities mention that initiation for innovation usually stems from the engineering and development practitioners. Their considerations when choosing innovations were listed as:

- Being afraid of the unknown, hence falling back on what is known
- No innovative solution is required
- Opinion on climate change
- Integration into the surrounding

However, the enthusiasm of the designers on climate adaptation is not affirmed by the asset management cluster for the following reasons:

- Uncertainties in performance and functioning
- Lack of maintenance knowledge
- Extra costs opposed to traditional methods
- Existing discourses

The maintenance concerns were found to be valid by the participants, as this is an important part of their work. In participant R's municipality, the past experiences with SuDS have left a negative discourse within their asset management department. Their reasoning was found to be caused by faulty execution, bad performance, or lack of maintenance (Participant R).
"What helps is to create an extra budget for the asset managers, because they have to find new methods for maintenance. I have worked on a large project, and demanded extra budget regarding the malfunctioning of the project" – Practitioner S

"Many products can be maintained with the same routine. This makes it easier for asset managers to maintain" – Practitioner P

Additionally, the utility companies are conservative (Participant P & S). They were found to be uncomfortable being situated under innovative solutions, this depends on where the innovative solution occurs.

REQUIREMENT KEY-AGENTS OF CHANGE

The requirement of initiators was a common concept in all municipalities, on an organizational scale from a policy perspective indications can be given. However, the taking of initiatives was in all of the municipalities limited by the engineers or spatial developers. The larger municipalities distinguished themselves through their climate adaptation experts which in all cases they were consultants with backgrounds in UWM. They were involved in and the initial project phase themselves. As these roles are not presented in the mid-sized municipalities, it is up to the available practitioners (e.g. sewer managers) to gather this knowledge from policymakers. These consultants have an intrinsic visionary vision. Intrinsic motivation was found to be limited to this specific group, hence they are required to initiate this towards their peers in the project groups.

"We join the project one time for consultation, which is where we leave it for the engineering consultancy where many engineers work that will have to integrate this into their routines" – Participant S

"Intern propositions occur on the regular, which is the consequence of integrally approaching the best design" – Participant A.

The notion is that when a project is established by the maintenance unit, it is up to a consultant how he interprets the surroundings and if he feels the necessity to take additional action in terms of climate adaptation when possible.

"Most colleagues that cooperate know each other already, however it took effort for this to occur. At the beginning of the coalition through risk Dialogues, we have tried to provide everyone with their own responsibility for climate change" – Participant A

Participant S, uses this notion that their readiness for experimentation has increased by using less drastically perceived solutions. The other participants agreed, that through the use of smaller steps in the adaptation process, the positive experiences may accumulate to get more difficult innovations through. Examples were provided that suggested leaving more sand between the tiles or guiding water to the flower patches.

SPREADING OF KNOWLEDGE ON INNOVATION

Within the respective municipalities, the knowledge sharing of different pilots was found to only be a problem by participant S. He finds that that the exchange of knowledge internally in the municipality as different asset managers are assigned to specific districts. However, the exchange of knowledge was not established. They can thus optimize their knowledge sharing internally. Participant A has not mentioned this factor, but states that the cooperation within their municipality has been strengthened by risk dialogues.

"You can show others that it works and remove their hesitation as it is new. Show them that the long-term benefits, the performance and the maintenance" – Participant P

The funding through the DPRA has enlarged the financial possibilities within municipalities, and their insights. However, the successive steps of the DPRA are still uncertain in terms of up-scaling technologies. Sharing of knowledge and experience between municipalities leaves much to be desired. The experiences of the start-ups themselves by demo setups on field labs were found to not be convincing by all participants. They would rather hear practical experiences from other municipalities.
Knowledge sharing was found to be important in the case studies for upscaling of the products. In the focus group, this was deemed similar. All participants agreed that there are municipalities in the Netherlands that have a lot of knowledge with (innovative) SuDS that could be of use by other municipalities.

"I haven't heard of active knowledge sharing between municipalities. However, there are initiatives like the Greenvillage and klimaatadaptatie.nl ... I think it should be showcased more actively. " – Participant P

Knowledge was found to be retained amongst direct circles of the municipalities (e.g. cooperations

involving waterboards, provinces, or surrounding municipalities). The only exception were the G4 meetings, and other symposia hosted on a national level (Participants A & S). It was recalled that there are 350 municipalities in the Netherlands, and even at the present state, there would be a ton of valuable knowledge to be used. Lastly, the symposia that were known were mostly catered towards designers and policymakers, but seemed to exclude the asset managers. This could be a major point of improvement as they are the end-users.

SUMMARIZING TABLE

The comparison of the case studies has been displayed in table form in table 7.2.

	Main similarities	**Main differences**
Drivers	- Dependence on national policies was found for kickstarting climate adaptive policies	- Adaptation strategy has been established in the larger municipalities - The MSP of larger municipalities takes into consideration a budget for experimentation.
Initiation	- All municipalities had experience of SUDS - Key agents of change are important to initiate innovative methods - Optimization of individual practitioner's routines both large and mid-sized hampers implementation - Opposition is mostly voiced by asset management and utilities concerning (extra) costs, maintenance and -Subsidies are deemed important in all municipalities - External expertise was required: - Based on knowledge & Capacity	- The larger municipalities have larger engineering consultancies for expertise - Due to the budgeting the implementation is often a political decision in smaller municipalities - Active sharing of knowledge has taken place in one larger municipality, in the smaller municipalities the communication can be improved.
Planning	- Availability of projects to link with the innovation	
Managin	- Spreading of knowledge should be initiated by the municipalities	- Spreading of knowledge is limited to circles or unknown by smaller municipalities

Table 7.2: Comparison of factors retrieved through case studies

7.3. SUMMARY OF EMPIRICAL RESULTS

7.3.1. DIFFERENCES IN EMPIRICAL FINDINGS

The main differences between large and mid-size dmunicipalities were found in the support by policies, allocated financial resources, and availability of initiating climate experts.
A sense of urgency has been formed by the national political attention on the organizational level, which seems to be the kick-starting factor for climate change for all municipalities taken into consideration except Rotterdam. The DPRA has stimulated the municipalities to execute stress-tests, creation of visions for 2050, and the issuing of subsidies through the IR.
All municipalities in the sample have executed stress tests and applied for subsidies through the IR. Visions for 2050 have been established in all municipalities too, however, in mid-sized municipalities, a strategy to reach these goals has not been formulated. The formulation of a strategy concerning an execution agenda, programs for experimentation, and strategy for actively incorporating climate change in scheduled projects have been established by larger municipalities.
The local political attention is found in the MSP in the larger municipalities, they have allocated budgets towards experimentation and knowledge development. This has not been found in the policies by the mid-sized municipalities and could be a part of the strategies. In the mid-sized municipalities allocation takes place or will take place through raising the sewer taxes. This budget should be available for interventions concerning groundwater levels and drainage of water (Participant R, P). Further strains are put on the budget as a consequence of the Participation law and competitiveness with other sustainability goals (e.g. energy transition vs climate adaptation).
On the practitioner's level, asset managers, spatial developers, and engineers are responsible for the implementation of the solutions. In the larger municipalities, they have access to their own engineering consultancies, of which usually at minimum a project manager and consultant are part of the project. They have more expertise in the data regarding their boundary conditions through geo-hydrological experts and GIS data.
The initiating parties in the larger municipalities do all seem to have a background in a combination of UWM and climate adaptation. These were also found to be part of the project team in the early stages. Their pool of colleagues with an interest in climate adaptation was found to be limited. This small group of initiators in the larger municipality has been spreading information through formal means within their organizations through online platforms, and by active information meetings. In the mid-sized municipalities, this is mostly limited to informal communication.
On the contrary, the colleagues concerning sustainability were mostly limited to policy writing in mid-sized organizations. The initiation was found to be dependent on the presence of a colleague that has an intrinsic motivation for innovative measures, however, without climate-adaptive experts on the practitioner's level this may be a hit or miss.
In mid-sized municipalities, due to the lack of budget, the higher-ups are usually involved. Depending on their perception and other relevant active topics, the extra budget may not be allocated. As a consequence of the limited budgets, the projects in mid-sized municipalities are smaller. The IR has made it possible for one-third of the costs associated with climate-adaptive solutions to be subsidized one time per year per municipality. This severely enlarged the climate adaptive budgets for mid-sized municipalities.

7.3.2. EMPIRICAL FINDINGS NOT LINKED TO SIZE DIFFERENCES

The main similarities were found in the considerations of practitioners. As mentioned before there are two parties involved: the asset managers and the engineers plus spatial development. The asset managers specify the renovations that have to take place, for which the developing team can introduce ideas. Reasons for not opting for innovative solutions were:

- Routine optimization by doing projects in a specific way for a long time
- The dilemma acting now or later to cope with climate change
- Not enough staff capacity to work on extra-curricular solutions

For the last factor, different interpretations were given. However, their reasons boiled down to not having enough knowledge concerning SuDS or being too busy thus disregarding other options outside of their routine. For both reasons, external consultancies were hired which possessed the knowledge to perform calculations regarding the innovations. The asset managers are the end-users of the construction their main factors were, they approve spending of the budget. Their main criteria concerning the technologies were found to be:

- The initial investment costs and maintenance costs
- The maintenance should fit into the norms
- Uncertainty in performance and lifespan of the construction
- Linking the innovation to an existing scheduled project
- Discourses concerning SuDS

An additional factor would be the trust in the initiators, which would mostly be endorsed by their status in the municipality. Their years of experience (senior function) and previous projects were found to be important. Lastly, in the case studies, it became apparent that a lot of attention has been paid to the implemented innovations through media attention and (international) conferences. The content that is shared within these conferences, is mostly catered towards policymakers and engineering consultants. However, an improvement was found to be made by adding in the asset managers. Furthermore, the mid-sized municipalities were found to be mostly involved in circles surrounding their geographical area (Province, Water Board, and Neighbouring municipalities). Whereas , the larger municipalities seemed to be involved in larger networks. The sharing of reports of monitoring and maintenance seemed to not be established fully, which is where another point of improvement was found regardless of municipal size.

7.3.3. THE REMAINING FACTORS IDENTIFIED FACTORS FROM EMPIRICAL RESEARCH

Some factors which have been identified in the case studies were not featured in the focus groups. The collaborative characteristics of the initiator seemed to be important in the case studies but haven't been mentioned in the case studies. The initiator should be capable of finding the right people in the organization, as there aren't as many options within a mid-sized organization due to the amount of staff involved. The obtaining of permits was found to be applicable in the case study of Rotterdam, for innovations that concern the drainage of rainwater and groundwater levels. The required permits were in this case issued by the Waterboard based on the Model Keur (2013). The issuing of this permit was subject to a modeling study, which could indicate that the quality and quantity of the infiltrated water would have no negative impacts on the surroundings. For the Bufferblock no specific permit was required for implementation by external parties. Potentially, the issuing of permits could delay the project. However, no hardships were found in the case studies. As all pilots were meant for obtaining knowledge, usually the innovations have a backup built-in. The presence of a backup lowers the amount of risk for practitioners and maintenance units. In both case studies, this was present, which was perceived as a positive factor for the mainstreaming process. The satisfaction of the involved stakeholders seemed to be highly relevant in both case studies, to some extent they were taken into consideration for the design. Their attitude was mostly indifferent to the technology as long as there were no negative impacts on their surroundings. Overall, if the information is adequately pitched towards the stakeholders in the area they were found to be cooperative. Lastly, the implementation phase has not been elaborated. The factors that occurred in

the case studies were attributed to the miscommunication with the utility company. Furthermore, an estimation of the groundwater levels had gone wrong through the use of GIS data in Rotterdam. This caused the buffer to fill with water, which increased the costs. Further factors concerning the execution of the project have not been discussed.

8

DISCUSSION

In this section, the results of the empirical research are related to the findings of the literature study. Based on the results practical recommendations are formulated in the next section. After which a reflection on the methodology and the limitations are presented.

8.1. VALIDATION OF EMPIRICAL RESULTS

In this section the results from the case studies and focus group have been related to the findings in literature.

8.1.1. TRANSITION THEORY

The innovations in both cases studies were applied to gain knowledge for evaluation of if the technology could be of future use for their municipalities. The innovation curve by Rogers (2010) describes the transition (Figure 2.2). It is difficult to classify municipalities into different adopter classes. In the empirical research, it came forward that two larger municipalities had already been pioneering in the field of SuDS with circular water use (UWB and Participant S). They could be categorized as early adopters, as this group is unafraid of potential setbacks due to their potential slack resources and social status.
However, in smaller municipalities, different innovations have been applied that have never been implemented before. These innovations are more revolutionary and applied on a smaller scale. Their choices of innovation relate more to the early majority of adopters. They are more discreet in their choice of innovations. In general, SuDS seem to be in the exploratory phase in the framework, which is still the phase before the take-off. Overall, the transition to sustainable UWM practice was found to be incremental, which could therefore be spanning across a long period (Marlow et al., 2013).

8.1.2. INFLUENCE OF NATIONAL POLICIES

The presence of national policies was found to be very relevant in the study by de Graaf et al. (2021). They took into consideration 32 factors, of which the presence of national policies that stimulated an overarching vision was ranked at 8th place (n = 65). In the case studies, the presence of the DPRA has stimulated the composition of a climate-adaptive vision and strategy for 2050. Five out of six municipalities in the interviews praised the DPRA for speeding up their climate-adaptive policies in the past year.

The availability of subsidies was found to be very relevant in every municipality that has participated in this study. However, the results by de Graaf et al. (2021), have indicated this to be a rather low scoring factor. This could be because they mainly focused on permeable pavement, which per definition is not necessarily more cost-intensive when only the pavement is replaced.

8.1.3. LOCAL POLICIES & STRATEGIES

LOCAL POLICIES THAT FACILITATE ALTERNATIVES AND EXPERIMENTATION

Policies that facilitate alternatives and experimentation were found to be the most important factor in Sweden, with unanimity of 73 - 84% (n = 318), This was found to be similar in the Netherlands, where political support ranked at third place (de Graaf et al., 2021). Even if there are political ambitions for climate adaptation, it could be that the budget is still insufficient. For example, in the budget specification for sustainability in Capelle, it was found that their MSP was not sufficient to cover the full maintenance, let alone the climate adaptive measures.
Biesbroek et al. (2011) elaborates deeper on the political support, as a difference in short-term and long-term issues in climate change was perceived (n = 432). This turned out to be the most important factor in their study, which took place in the Netherlands. Climate adaptation competes with short-term issues for political attention and budget allocation. In my study it emerged that decentralization of tasks was perceived to be the cause of budget shifting within mid-sized municipalities, examples were youth services and the participation law (Interviewee 4 & 10). Furthermore, the results of this study indicate that in the mid-sized municipalities competition could be present between the budgets specified in the sustainability program.

The budgets in smaller municipalities according to the MSP are smaller. However, no data was involved concerning the fiscal health of the participating municipalities. Hence, there are no insights into their slack resources. Based on the MSPs, larger municipalities do have a larger budget to be spent on the gathering of knowledge and experimentation. This implies that they could be less dependent on the subsidies by external parties as opposed to mid-sized municipalities.

STRATEGIES THAT FACILITATE CLIMATE ADAPTIVE MEASURES

Strikingly, the formulation of a strategy was not mentioned in the Dutch literature studies. But it did emerge as an important factor in the study by Cettner et al. (2014). The drafting of a stormwater strategy was rated as very effective by the survey participants (80-89% unanimously). To corroborate this notion, Biesbroek et al. (2011) found that the lack of long-term impacts in policies could be a barrier to implementation. The water department in the study of Cettner et al. (2014), was fond of the notion of having long-term strategies integrated within policies. However, the spatial development team found that it was more important to have strategies on the practitioner's level. The truth seems to be somewhere in between according to the results of the empirical research in this study. It was found that strategies that directly impact the practitioners were applied, such as including climate adaptation in the program of requirements for renovation projects. Strategies were still found to be lacking in mid-sized municipalities, however, if the steps to the DPRA are followed they will be properly established by 2023.

8.1.4. KEY-AGENTS OF CHANGE

The support for SuDS has not been widely built into any of the organizations yet. In the empirical results, it was found that agents of change for climate adaptation are mostly found in the spatial development and engineering units. The presence of those people was found to be the second most important factor in the research by Cettner et al. (2014). The results indicate that 79% of the par-

ticipants underlined the importance of the UWM unit portrayed perseverance, this was 68% for the spatial development unit. Koop et al. (2017) conducted a similar study in the Netherlands, where governance capacity was tested for adaptability to climate change. They found that different agents of change were required, which were: 1) entrepreneurial, 2) collaborative, and 3) visionary.
Entrepreneurial or initiating agents of change were found to be the most important for accomplishing sustainable changes. This was respectively followed by visionary and collaborative. Initiators were found to be the most important, thus taking the first step to break out of their daily routines. These initiators having a long-term vision on climate change and being socially adept were additional characteristics that could help to create more organizational support.
In the larger municipalities, it was found that the initiators had a mixed background between climate adaptation and UWM, which are more suitable for this long-term vision. Additionally, it came forward that they had built a reputation through previous projects. ”
Climate adaptive roles were mostly limited to policy writers in the mid-sized municipalities. Till now, this has not been found in other studies. The lack of climate experts on the practitioner's level could be an indication of less initiation happening in mid-sized municipalities. In Capelle, without the obtaining of the grant, no action would have been taken. Similarly, in the mid-sized municipality of R, it was named that people have to cross boundaries outside of their daily tasks. Due to the lack of pressure of the policies, the initiation is further discouraged.
The key characteristics of the key agents of change were found to apply to the initiators in the case studies where they created support on the practitioner's level within the project teams. This was another criterion that was found to be highly relevant in the study by de Graaf et al. (2021).

8.1.5. SUPPORT ON THE PRACTITIONER'S LEVEL

On the practitioner's level at the engineers and spatial development unit, it was found that their lack of initiation of SuDS was attributed to routines, dilemmas, and staff capacity. The establishment of routines was developed by doing projects following a certain procedure for too long. The concept of learning effects by Uittenbroek (2016) was found to be of high relevance. The learning effects find that when a routine is used repetitively, an actor optimizes this routine through learning effects. A side effect is that actors become stuck in this routine. The routine formation may cause them to dismiss other options in UWM such as SuDS which could benefit them. Uittenbroek et al. (2013), found that exploratory learning should be therefore be promoted. Secondly, the dilemma of acting now or later to cope with climate change was found to be a choice that was up to the specific practitioner. However, as mentioned before, wide support is still lacking at the practitioner's level. The formation of support is mostly facilitated by having a supportive organizational culture, which was found to be the third most important factor by Cettner et al. (2014). However, seemed to find no support by the participants in the study by de Graaf et al. (2021). The truth may be somewhere in between, as other factors such as experience with SUDS, key agents of change, policies, and strategies can certainly influence their thought process. Lastly, the size of the organization can influence the amount of practitioners that can dedicate themselves to the topic.
Having a smaller staff capacity to work within mid-sized municipalities, this was attributed in the empirical results to: 1) a lack of knowledge concerning SuDS and 2) a lack of time for additional solutions. This last factor was found to be the fourth important factor in the research by Cettner et al. (2014).

The factors by the asset managers relate mostly to the findings on technological level by de Graaf et al. (2021), of which the most important factors were found to be:

1. Expected performance of technology
2. Predicted effects on surroundings

3. Predicted costs of maintenance and monitoring
4. Investment costs

In the empirical findings, the predicted cost of the investment together with the expected performance was found to be the most important factor. Which was followed by the predicted costs of maintenance and monitoring.
Additionally, a lack of maintenance knowledge was found to be a barrier for the asset managers too, which was found to be a large part of their opposition. It was found to be beneficial if the maintenance would fit into the current practices. An example was the Bufferblock, for which maintenance has not been planned explicitly, but was scheduled to be done through high-pressure cleaning. If the maintenance and performance are up to standards, this would minimize the discourses concerning SuDS as these experiences were found to discourage practitioners from further implementation. Lastly, the availability of linking implementation of innovation to a scheduled project was considered a highly valued factor in the empirical research. However, it did come forward by having boundary conditions that could require an innovative intervention.

8.1.6. SPREADING OF KNOWLEDGE AFTER IMPLEMENTATION

The most important adopters according to the adoption curve by were found to be the innovators and early adopters, these were found to be the main inspiration for the other adopters to follow (Rogers, 2010). The current adopters, fall into those categories. Hence, the reviews from those groups are of major importance for stimulating further adoption.

Similarly in the focus group, it was proposed that the implementation of unknown SuDS in the municipalities should be followed up by a monitoring scheme. Naturally, maintenance also follows if this has been established correctly. However, the knowledge seems to be mostly retained internally in the municipality. Participant S, even mentioned that as their municipality is larger, internal fragmentation forms a barrier to knowledge distribution amongst different colleagues. The other two larger municipalities mention that they share the knowledge through risk dialogues (Participant A) or through meetings and conferences (Interviewee 6). In the smaller municipalities, this was found to be established through informal procedures, but as the organization was smaller this would be established more easily. As two out of three municipalities did only start implementation recently, the upscaling did not take place yet. Participant R mentioned that due to their bad experiences with SuDS, no upscaling has taken place yet due to discourse formation. Therefore, it is not possible to state a verdict on the issue of internal knowledge sharing based upon the findings. On the contrary, Ford (2009), indicates that the internalizing of a occurs refreezing phase (see Chapter 2). While larger organizations have a structural approach to the incorporation of a new change in their organization, in smaller organizations this is usually done in an informal manner .

The further dispersion of knowledge has only been mentioned in the study by de Graaf et al. (2021). It was mentioned that the first steps have been set, but that there's still room for improvement. The empirical results indicate that there's room for improvement as well. It was found that currently knowledge dispersion is mostly stuck in local circles and minimal conferences and limited to policymakers, engineers, and spatial developers. Additionally, websites such as climatescan.nl and klimaatadaptiefnederland.nl have been named. However, active knowledge sharing was found to be lacking for mid-sized municipalities. The knowledge of the larger municipalities was found to be mostly limited between the G4 municipalities, and to an extent, their surrounding municipalities.

8.2. RECOMMENDATIONS FOR PRACTICE

Different recommendations are suggested in this section to cope with the different barriers that have been identified in the previous section.

INCREASING THE BUDGET ALLOCATION

The first implication is that there aren't enough policies that facilitate experimentation by allocation of budgets in mid-sized municipalities. However, there are pressures by competing issues and relatively smaller sewer tax income as opposed to larger municipalities. Therefore, it would be highly unlikely for extra budget allocation to be organized by shifting budgets towards climate change in these municipalities. As stress tests have been conducted, pressing issues could be initiated to the higher-ups, which could lead to a shift in priorities on the sustainability agenda towards climate adaptation.
The budget estimates of the mid-sized municipalities aside from the IR, do not offer sufficient coverage.
The IR offers a solution to this in the short term, which offers funding in the period of 2021 - 2023. However, the funding issued during this period was anticipated to not be enough for all of the climate adaptive measures to take place.
Structurally, more budget is required by the government for climate adaptation after the IR has passed. For now, a solution has been named of increasing the sewer taxes (+/- 10%), which is applied to decentralization (including implementation of SuDS). This may lead to a higher field of play in the short term, but concerns for the future were implied regarding this source of income (citizen opposition). In the future aside from this budget, extra stimulation through the government similar to the IR may be required.
Furthermore, facilitation of knowledge sharing through the participants of the IR could benefit most municipalities to gain insights into the cost and benefits of SuDS.

ESTABLISHMENT OF A LOCAL STRATEGY

The mid-sized municipalities have been following the DPRA. As consequence documents concerning ambitions for 2050 and stress tests have been conducted. However, strategies to reach those goals have not been determined yet. Innovations are usually implemented as an extra, regardless of organizational size. But per definition, they are not necessarily more expensive if they were to replace certain infrastructure. The expansion of the use of the current MSP budgets for SuDS in addition to traditional sewer systems allows for their consideration in projects. It's a "nice to have" right now, but it could become a "must-have". Other strategies that have been named in the larger municipalities have been:

1. Strategies which allow climate adaptation to be taken into consideration as a boundary condition or referring to the stress-test in the preliminary design phase
2. Risk dialogues internally in the organization
3. Starting with small measures and slowly expanding to more drastic measures

The first strategy would also be a viable solution to break through the optimized routines by engineers and spatial developers. Currently, the stress tests are a good initiative that may be handy for entrepreneurs to evaluate if there is a need for their innovation in a certain municipality. Additionally, by taking climate adaptive measures into consideration in the preliminary design phase, the team can form an impression of its benefits compared to traditional solutions. The picking of climate adaptive measures can be further enhanced by risk dialogues as was brought forward by Participant A, where everyone is aware of the problem.

Lastly, both projects mentioned within this document are rather large, for Capelle it was exceptional that they implemented Bufferblocks on large scale for the first time. However, when climate adaptation is not as lively within an organization it may be beneficial to start small to plant a seed within the organization. This lowers the threshold risk-wise, for maintenance and for designers. When different low-risk interventions have been implemented, it may become easier to a project on a larger scale. In addition, this is a recommendation for the innovation market as well, the conceptualization of less cheap solutions.

LACK OF CLIMATE ADAPTIVE EXPERTS AT PRACTITIONER'S LEVEL

As there is a lack of climate-adaptive expertise on the practitioner's level, improvement of the expertise of UWM experts on climate adaption could be beneficial for implementation as mentioned above. This could be accomplished by creating awareness on the topic which is done through policies and initiatives such as the Waterstraat. However, it could be further enhanced by offering specific training.

ASSET MANAGER RESISTANCE

To cope with the uncertainty in the investment and maintenance costs it could be highly beneficial if startups made cost-benefit analyses upfront of their products that could be presented, rather than just the product.
The Bufferblock specified its tendering and maintenance procedures on the website. The latter seems to be highly valued by the maintenance unit, as they can determine whether there are familiar maintenance techniques that can be applied. Similarly, it could be of high value to specify maintenance procedures for the products so the asset management unit does not have to think about this issue when an innovation is proposed.

SHARING OF KNOWLEDGE AFTER IMPLEMENTATION

There are 355 municipalities in the Netherlands, of which municipalities such as Rotterdam seem to have a lot of knowledge concerning climate adaptation. Monitoring and maintenance have taken place in such pioneering organizations for a while, hence there are a lot of learning opportunities for municipalities that aren't as advanced yet. Practical experiences from the designers could make it easier for implementation in the future. From a maintenance perspective, it means that this innovation does not have to be monitored and implemented again to gain knowledge as it is already there. Additionally, with these practical experiences, the same mistakes do not have to be made again. Furthermore, smaller municipalities do not want to take the risk on innovative projects that have only been tested in demo situations, for which the vendor provides most of the testing information. Larger municipalities that have a larger playing field sharing their knowledge could alleviate this barrier. This could also hint towards standardization of requirements that should be set on SuDS.

There are different platforms, such as climatescan.nl and klimaatadaptatienederland.nl. Other ways of sharing are through initiatives where different municipalities are working together. However, interviewees have indicated that the sharing of knowledge is not actively pursued. Fragmentation between different municipalities has been named, so that knowledge stays put within municipalities. Most policies and strategists are involved in the sharing of knowledge at the moment, it would be beneficial if maintenance properties would be shared. The DPRA has facilitated knowledge gathering for municipalities, the next step should be the distribution of knowledge. Online symposia may facilitate this development as it lowers the bar for initiation.

8.3. LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

In this section the limitations of the study are elaborated, including the impacts on the results and recommendations for additional research.

REFLECTION ON METHODOLOGY

Firstly, an implication of choosing case studies as methodology, is that they have to be representative of a larger sample size. The validity of the thesis could be strengthened by performing this study on larger scale. An example would be to distribute a questionnaire amongst the mid-sized municipalities. This has been related to the external validation in Chapter 4. To improve the external validity, the results have been compared to experiences of other municipalities and scholars (triangulation). The case studies that have been chosen have been sampled based on their similar boundary conditions and the primary implementation cycle of an innovation taking place. Doing so allowed for the socio-institutional differences to become more apparent.

As a follow-up, it could be argued that the specification of the case studies has limited the number of interviewees per municipality, however, their answers in the interviews were found to support each other. As the participants were found to be limited, it did not make sense to weigh the importance of factors in the empirical research, but was instead incorporated through the literature study in the discussion.

The structure of the data gathering was based on the provided documentation, policy documents, and semi-structured interviews. Another method to apply the framework would be to frame the municipality itself as a case study, so that more participants could be interviewed. Additionally, it would then make more sense to investigate how different factors would be ranked.

EVALUATION OF POTENTIAL NECESSITY OF INNOVATIONS

Within the municipalities that were taken into consideration for the research, the necessity was mostly based on land-subsidence, lack of underground space, high groundwater levels, and of course a sense of urgency for climate adaptation. Not every municipality has the same (geo)hydrological characteristics, hence the necessity for innovations may be different. The sample of the study did mention those problems, however, it could be different in other parts of the Netherlands. A recommendation for further research would be to look into those conditions on a national scale, as the relevance is speculated to differ per region.

TAKING INTO CONSIDERATION THE PERSPECTIVE OF VENDORS VS MUNICIPALITIES

The framework that has been applied is predominantly focused on the socio-institutional component of the case studies. Which takes into consideration the experiences of the vendors surrounding their first implementation. However, the upscaling from the entrepreneurial perspective has not been elaborated. Similarly, in the focus group, it became apparent that the vendors may have a different vision than municipalities for the timeline of upscaling. Vendors envision this to be quicker than municipalities have the capacity for, which may be interesting to research further.

EXPLORING OUTSIDE OF THE SCOPE OF THE STUDY

The scope of the study is focused on clients in the Netherlands at the public level, which was limited to mid-sized and larger municipalities. The results are therefore mostly based on this group, incorporation of the smaller municipalities in the Netherlands could indicate a different decision-making

process, as fewer staff members are likely available. Furthermore, the public level has been investigated in this study, but homeowners in the Netherlands are responsible for the drainage of rainwater on their properties. Their criteria in the adoption process could be different.

FURTHER MARKET EXPLORATION

Lastly, the study takes into consideration innovations that originated from The Green Village at the TU Delft. The study has predominantly focused on participants in their network that had experience with innovations from this same origin. There may be other market vendors which are competing with those innovations, it may be interesting to perform a market analysis on the market of SuDS to evaluate which markets may be the least saturated or most promising.

9

CONCLUSION

To protect the urban environments against the potential pluvial flooding, changes must be made in urban stormwater management. According to my knowledge, this study is the first in the field that has explored the importance of the size of municipalities on the implementation of SuDS. The initial problem statement was formulated by VPdelta, which addressed that the vendors at their field labs found the adoption of their innovations to be lacking. The study tries to find answers answers and possible solutions for the uptake of their innovations. Additionally, this topic is interesting for municipalities and scholars to gain insights into how mainstreaming of SuDS can take place.
Studies, which took place in the Netherlands, assessed the drivers and barriers in municipalities. However, in their studies, they predominantly focused on larger municipalities or generalizations for all municipalities. The mid-sized municipalities form a significant portion of the market in the Netherlands. The main question posed in this study is to find out if and explain to what extent the mainstreaming capacity towards implementing SuDS innovations between different sized municipalities differs. Furthermore, as a consequence of the identified factors, different recommendations were specified.
In this paper, a conceptual mainstreaming framework was developed, which was found applicable to the case studies in terms of reconstruction of the scenarios and allowing for a comparative analysis of the applicable factors. According to the MLP by Geels (2002b), three levels are interacting during the climate adaptive transition: the landscape, the regime, and the niche level. The regime was described as the socio-institutional component of the urban environment, else said the decision-making process in the municipalities. Drivers were found to be pressures from the landscape which form a sense of urgency, these were established as national policies or local policies. Furthermore, within the framework, different phases are present within the mainstreaming process that occurs in the socio-institutional regime. The initiation phase consists of the formation of understanding, willingness, and enabling. This is followed by the planning of a project, where different options are weighed. And finally, implementation takes place followed by an evaluation.
In addition, to the phases model, different factors were linked to each phase (see Table 3.3.). For which most of the relevant factors were found in the drivers, initiation, and managing phase. Authors have indicated that the nature of the adoption of these innovations was found to be incremental, which means that a radical shift in the regime is not likely to happen. Even in the larger municipalities, the support by all three involved groups seems limited and mixed. In essence, it comes down that through time more experimentation will take place, more budget will be allocated, and urban water challenges will most likely be more prominent. However, that doesn't that there

isn't room for improvement in the short term.
The overall results from the empirical research yield that climate adaptation currently seems to be embedded in political planning and ambitions in mid-sized municipalities. Additionally, the formulation of climate adaptive ambitions by municipalities may give the impression that climate adaptation is further mainstreamed than it is in reality. Contrarily, the national government is making climate adaptation a more lively topic by facilitating funding and strategy development through the DPRA in the past few years.
The empirical research results indicate that socio-institutional barriers are in place which has to be overcome. Valuable lessons can be drawn from large-sized municipalities in that regard:

- Formulation of strategies that structurally integrate climate change at practitioner's level.
- Allocation of additional budget for experimentation and knowledge gathering
- Facilitation of climate adaptive expertise at practitioner's level

Within the initiation, phase resistance was found in both the designer and asset manager perspectives. For which the former group was found to be rather supportive, and the latter more skeptical. The skepticism could be mostly taken away by creating more awareness on the topic, having insights into the lack of expertise that the asset managers require. Supportive documentation was found to be in the cost-benefit analyses, hydrological performance, and maintenance and monitoring procedures.

Another key factor in that regard is that there is a lack of information sharing of experiences with SuDS between municipalities in the Netherlands. Hence, knowledge is detained in municipalities or their surrounding network. The sharing of knowledge should be promoted so that other municipalities can learn from those experiences and won't have to make the same mistakes. In addition, the sharing of knowledge is now catered towards engineers, spatial developers, and policymakers. It would be logical to involve the asset managers in these settings as well.
All in all, SuDS offer a viable solution in becoming more climate adaptive, and vice-versa climate adaptive mindsets can facilitate the implementation of SuDS. It will take time for SuDS to become mainstream, but the identified factors offer insights into how to accelerate this process.

BIBLIOGRAPHY

Adem Esmail, B. and Suleiman, L. (2020). Analyzing evidence of sustainable urban water management systems: a review through the lenses of sociotechnical transitions. *Sustainability*, 12(11):4481.

Arahuetes, A. and Olcina Cantos, J. (2019). The potential of sustainable urban drainage systems (suds) as an adaptive strategy to climate change in the spanish mediterranean. *International Journal of Environmental Studies*, 76(5):764–779.

Bechky, B. A. (2003). Sharing meaning across occupational communities: The transformation of understanding on a production floor. *Organization science*, 14(3):312–330.

Berry, J. N. and McGreal, W. S. (2003). *European cities, planning systems and property markets*. Routledge.

Biesbroek, R., Klostermann, J., Termeer, C., and Kabat, P. (2011). Barriers to climate change adaptation in the netherlands. *Climate law*, 2(2):181–199.

Boogaard, F. and Lucke, T. (2019). Long-term infiltration performance evaluation of dutch permeable pavements using the full-scale infiltration method. *Water*, 11(2):320.

Boogers, M., Schaap, L., Karsten, N., and Van den Munckhof, E. (2008). Decentralisatie als opgave: Een evaluatie van het decentralisatiebeleid van de rijksoverheid (1993-2008).

Braun, V. and Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. sage.

Brodnik, C., Brown, R., et al. (2017). The co-evolution of institutional logics and boundary spanning in sustainability transitions: the case of urban stormwater management in melbourne, australia. *Environment and Natural Resources Research*, 7(3):36–50.

Brown, R. and Farrelly, M. (2008). Sustainable urban stormwater management in australia: professional perceptions on institutional drivers and barriers. In *Proceedings of the 11th International Conference on Urban Drainage*, volume 31. Citeseer.

Brown, R. R. and Farrelly, M. (2009). Challenges ahead: social and institutional factors influencing sustainable urban stormwater management in australia. *Water science and technology*, 59(4):653–660.

Bryman, A. (2008). Of methods and methodology. *Qualitative Research in Organizations and Management: An International Journal*.

Carlsen, B. and Glenton, C. (2011). What about n? a methodological study of sample-size reporting in focus group studies. *BMC medical research methodology*, 11(1):1–10.

CAS, S. (2021). *Aanpak klimaatadaptatie door gemeenten - een kwalititatieve analyse*. na.

Cettner, A., Ashley, R., Hedström, A., and Viklander, M. (2014). Assessing receptivity for change in urban stormwater management and contexts for action. *Journal of environmental management*, 146:29–41.

De Graaf, R., Dahm, R., Icke, J., Goetgeluk, R., Jansen, S., and Van De Ven, F. (2009). Receptivity to transformative change in the dutch urban water management sector. *Water science and technology*, 60(2):311–320.

de Graaf, R., Leskens, A., Veldkamp, T., Kluck, J., and Boogaard, F. (2021). From pilot projects to transformative infrastructures, exploring market receptivity for permeable pavement in the netherlands. *Sustainability*, 13(9):4925.

de Graaf-van Dinther, R., Leskens, A., Veldkamp, T., Kluck, J., and Boogaard, F. (2021). From pilot projects to transformative infrastructures, exploring market receptivity for permeable pavement in the netherlands. *Sustainability*, 13(9):4925.

Deely, J., Hynes, S., Barquín, J., Burgess, D., Finney, G., Silió, A., Álvarez-Martínez, J. M., Bailly, D., and Ballé-Béganton, J. (2020). Barrier identification framework for the implementation of blue and green infrastructures. *Land Use Policy*, 99:105108.

Denzin, N. K. (1978). Triangulation: A case for methodological evaluation and combination. *Sociological methods*, pages 339–357.

Dewar, R. D. and Dutton, J. E. (1986). The adoption of radical and incremental innovations: An empirical analysis. *Management science*, 32(11):1422–1433.

Drosou, N., Soetanto, R., Hermawan, F., Chmutina, K., Bosher, L., and Hatmoko, J. U. D. (2019). Key factors influencing wider adoption of blue–green infrastructure in developing cities. *Water*, 11(6):1234.

Dunn, G., Brown, R., Bos, J., and Bakker, K. (2017). The role of science-policy interface in sustainable urban water transitions: Lessons from rotterdam. *Environmental Science & Policy*, 73:71–79.

Esteban, T. A. O., Edelenbos, J., and van Stapele, N. (2020). Keeping feet dry: Rotterdam's experience in flood risk and resilience building. In *Flood Impact Mitigation and Resilience Enhancement*. IntechOpen.

Field Factors, K. (2016). Micro urban wetlands - ontwerpend onderzoek naar kleinschalige waterbuffers in de stad.

Fletcher, T. D., Shuster, W., Hunt, W. F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J.-L., et al. (2015). Suds, lid, bmps, wsud and more–the evolution and application of terminology surrounding urban drainage. *Urban water journal*, 12(7):525–542.

Ford, M. W. (2009). Size, structure and change implementation: An empirical comparison of small and large organizations. *Management Research News*.

Freeman, C. (1994). The economics of technical change. *Cambridge journal of economics*, 18(5):463–514.

Geels, F. W. (2002a). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, 31(8-9):1257–1274.

Geels, F. W. (2002b). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, 31(8-9):1257–1274.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research policy*, 33(6-7):897–920.

Geels, F. W. and Kemp, R. (2012). *The multi-level perspective as a new perspective for studying socio-technical transitions*. na.

Geels, F. W. and Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, 36(3):399–417.

Gemeente Capelle (2018). Verslag projectgroep star2cs - voortgangsoverleg. *Gemeente Capelle*.

Gemeente Capelle (2015). Verbreed gemeentelijk rioleringsplan 2016-2020.

Gemeente Capelle (2017). Programma van eisen - werken in de openbare ruimte. *Gemeente Capelle*.

Gemeente Capelle (2019). Ideeen keuzematrix versie 2 01-11. *Gemeente Capelle*.

Gemeente Rotterdam (2014). Presentatie stadsontwikkelingferry pronk. https://docplayer.nl/10250413-25-juni-2014-presentatie-stadsontwikkeling-ferry-pronk.html.

Gemeente Rotterdam (2015a). Asr stedelijk rotterdam - voortgangsoverleg met externe partijen - 10 nov 2015.

Gemeente Rotterdam (2015b). Plan van aanpak haalbaarheid aquifer storage and recovery in het rotterdams stedelijk gebied - verkenning van potentiele locaties en uitwerking van een locatie voor toepassing.

Gemeente Rotterdam (2015c). Projectplan verkenning potentiele locaties voor waterbuffer in rotterdam 27 juli 2015.

Gemeente Rotterdam (2016a). Asr verslag 4 feb - 2016.

Gemeente Rotterdam (2016b). Gemeentelijk$_{r}ioleringsplan$ – 2016 – 2020.

Gemeente Rotterdam (2016c). Kostenraming haalbaarheids onderzoek asr rotterdam - 17 feb 2016.

Gemeente Rotterdam (2016d). Prioriteiten en indicatoren. https://jaarstukken2016.rotterdam.nl/p126797/prioriteiten-en-indicatoren.

Gemeente Rotterdam (2016e). Ruimtelijke plannen, spangen, samenwerking met de waterbeheerder. https://www.ruimtelijkeplannen.nl/documents/NL.IMRO.0599.BP1035Spangen-oh01/t_NL.IMRO.0599.BP1035Spangen-oh01_5.2.html.

Gemeente Rotterdam (2017a). Aanvraag toekenning productsturing.

Gemeente Rotterdam (2017b). Toekomstbestendige waterpleinen. https://www.rotterdam.nl/wonen-leven/toekomstbestendige-waterpleinen/.

Gemeente Rotterdam (2017c). Water en omgeving rondom sparta - 16 jan 2017.

Gemeente Rotterdam (2020). Rotterdams weerwoord urgentiedocument.

Gerring, J. (2008). Case selection for case-study analysis: Qualitative and quantitative techniques. In *The Oxford handbook of political methodology*.

Gilbert, N. and Stoneman, P. (2015). *Researching social life*. Sage.

Grin, J., Rotmans, J., and Schot, J. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*. Routledge.

Hamann, F., Blecken, G.-T., Ashley, R. M., and Viklander, M. (2020). Valuing the multiple benefits of blue-green infrastructure for a swedish case study: Contrasting the economic assessment tools b£ st and teeb. *Journal of Sustainable Water in the Built Environment*, 6(4):05020003.

Hamin, E. M., Gurran, N., and Emlinger, A. M. (2014). Barriers to municipal climate adaptation: Examples from coastal massachusetts' smaller cities and towns. *Journal of the American Planning Association*, 80(2):110–122.

Haveman, H. A. (1993). Organizational size and change: Diversification in the savings and loan industry after deregulation. *Administrative science quarterly*, pages 20–50.

Hegger, D. L., Van Vliet, J., and Van Vliet, B. J. (2007). Niche management and its contribution to regime change: the case of innovation in sanitation. *Technology Analysis & Strategic Management*, 19(6):729–746.

Jeffrey, P. and Seaton, R. (2004). A conceptual model of 'receptivity'applied to the design and deployment of water policy mechanisms. *Environmental Sciences*, 1(3):277–300.

Kiparsky, M., Sedlak, D. L., Thompson Jr, B. H., and Truffer, B. (2013). The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*.

Koop, S., Koetsier, L., Doornhof, A., Reinstra, O., Van Leeuwen, C., Brouwer, S., Dieperink, C., and Driessen, P. (2017). Assessing the governance capacity of cities to address challenges of water, waste, and climate change. *Water Resources Management*, 31(11):3427–3443.

KWR (2019). Urban waterbuffer spangen: Resultaten.

KWR, Wareco, CODEMA, and Fieldfactors (2016). Projectplan tki urban waterbuffer (uwb).

KWR, Field Factors, G. (2016). Verkennend onderzoek spangen.

Leedy, P. D. and Ormrod, J. E. (2005). *Practical research*, volume 108. Pearson Custom Saddle River, NJ.

Lehmann, M., Major, D. C., Fitton, J., Doust, K., and O'Donoghue, S. (2021). The way forward: Supporting climate adaptation in coastal towns and small cities. *Ocean & Coastal Management*, 212:105785.

Lewin, K. (1947). Frontiers in group dynamics: Concept, method and reality in social science; social equilibria and social change. *Human relations*.

Marlow, D. R., Moglia, M., Cook, S., and Beale, D. J. (2013). Towards sustainable urban water management: A critical reassessment. *Water research*, 47(20):7150–7161.

Martin, Major, Lehmann, D. C., Fitton, J. M., Doust, K., and O'Donoghue, S. (2021). Towards a typology for coastal towns and small cities for climate change adaptation planning. *Ocean & Coastal Management*, 212:105784.

McCarthy, J. (1998). Reconstruction, regeneration and re-imaging: the case of rotterdam. *Cities*, 15(5):337–344.

Merriam, S. B. and Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Moore, T. (2018). *Urban SustainabilityTransitionsAustralian Cases-International Perspective*. Springer.

Moser, S. C. and Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the national academy of sciences*, 107(51):22026–22031.

Nelen en Schuurmans (2019). Klimaatadaptatie in capelle a/d ijssel.

Nguyen, T. T., Ngo, H. H., Guo, W., Wang, X. C., Ren, N., Li, G., Ding, J., and Liang, H. (2019). Implementation of a specific urban water management-sponge city. *Science of the Total Environment*, 652:147–162.

Nieuwkerk, E. v., Trouwborst, R., Junier, S., Mostert, E., Rutten, M., Nederlof, J., Maarleveld, M., and Geerse, J. (2010). *Klimaatverandering en het Rotterdamse stedelijk watersysteem: Verkennende studie en agenda voor vervolg*. Gemeente Rotterdam.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global environmental change*, 19(3):354–365.

Pettigrew, A., Ferlie, E., and McKee, L. (1992). Shaping strategic change-the case of the nhs in the 1980s. *Public Money & Management*, 12(3):27–31.

Qiao, X.-J., Kristoffersson, A., and Randrup, T. B. (2018). Challenges to implementing urban sustainable stormwater management from a governance perspective: A literature review. *Journal of Cleaner Production*, 196:943–952.

Raven, R., Van den Bosch, S., and Weterings, R. (2010). Transitions and strategic niche management: towards a competence kit for practitioners. *International Journal of Technology Management*, 51(1):57–74.

Rijkswaterstaat (2016). Watersnoodramp 1953. https://www.rijkswaterstaat.nl/en/water-systems/protection-against-water/the-flood-of-1953.

Rip, A., Kemp, R., et al. (1998). Technological change. *Human choice and climate change*, 2(2):327–399.

Rogers, E. M. (1971). Social structure and social change. *American Behavioral Scientist*, 14(5):767–782.

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Rotmans, J., Kemp, R., and Van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *foresight*.

Roy, A. H., Wenger, S. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., Shuster, W. D., Thurston, H. W., and Brown, R. R. (2008). Impediments and solutions to sustainable, watershed-scale urban stormwater management: lessons from australia and the united states. *Environmental management*, 42(2):344–359.

RVO (2021). Pps-toeslag onderzoek en innovatie. https://www.rvo.nl/subsidie-en-financieringswijzer/pps-toeslag-onderzoek-en-innovatie.

Segrave, A. A., van der Zouwen, M. M., and van Vierssen, W. W. (2014). Water planning: from what time perspective? *Technological Forecasting and Social Change*, 86:157–167.

Slob, A. and Duijn, M. (2014). Improving the connection between science and policy for river basin management. In *Risk-Informed Management of European River Basins*, pages 347–364. Springer.

Stead, D. (2014). Urban planning, water management and climate change strategies: adaptation, mitigation and resilience narratives in the netherlands. *International Journal of Sustainable Development & World Ecology*, 21(1):15–27.

STOWA (2016). Ondergronds bergen en terugwinnen van water in stedelijk gebied: een verkenning van de (on)mogelijkheden. https://edepot.wur.nl/371586.

STOWA (2019). Neerslagstatistieken -reeksen voor het waterbeheer 2019.

Suleiman, L. (2021). Blue green infrastructure, from niche to mainstream: Challenges and opportunities for planning in stockholm. *Technological Forecasting and Social Change*, 166:120528.

Tauw (2019). Monitoringsplan waterweg arica star2c's - capelle a/d ijssel. *Sociological methods*.

Tushman, M. L. (1977). Special boundary roles in the innovation process. *Administrative science quarterly*, pages 587–605.

Uittenbroek, C. (2014). *How mainstream is mainstreaming?: The integration of climate adaptation into urban policy*. Utrecht University.

Uittenbroek, C. J. (2016). From policy document to implementation: organizational routines as possible barriers to mainstreaming climate adaptation. *Journal of Environmental Policy & Planning*, 18(2):161–176.

Uittenbroek, C. J., Janssen-Jansen, L. B., and Runhaar, H. A. (2013). Mainstreaming climate adaptation into urban planning: overcoming barriers, seizing opportunities and evaluating the results in two dutch case studies. *Regional environmental change*, 13(2):399–411.

Van der Brugge, R. (2009). *Transition dynamics in social-ecological systems: the case of Dutch water management*.

Van der Brugge, R. and De Graaf, R. (2010). Linking water policy innovation and urban renewal: the case of rotterdam, the netherlands. *Water Policy*, 12(3):381–400.

Van der Brugge, R. and Rotmans, J. (2007). Towards transition management of european water resources. *Water Resources Management*, 21(1):249–267.

Van der Vleuten, E. and Raven, R. (2006). Lock-in and change: Distributed generation in denmark in a long-term perspective. *Energy policy*, 34(18):3739–3748.

Veldkamp, Schoenmaker, K. (2020). Functioneren infiltrerende verharding in de praktijk.

Vries, R. d., Vringer, K., Wentink, C., and Visser, H. (2019). Gemeentelijke bestuurskracht en de energietransitie. *PBL Netherlands Environmental Assessment Agency, The Hague*.

Waternet (2016). Gemeentelijk rioleringsplan amsterdam.

Waterwet art. 3.4 lid 1 & 2 (2021). Waterwet art. 3.4 lid 1 & 2. https://wetten.overheid.nl/BWBR0025458/2020-07-01/0/Hoofdstuk3/Paragraaf1/Artikel3.4/informatie.

Waterwet art. 3.5 (2021). Waterwet art. 3.5. https://wetten.overheid.nl/BWBR0025458/2020-07-01/0/Hoofdstuk3/Paragraaf1/Artikel3.5/informatie.

Waterwet art. 3.6 (2021). Waterwet art. 3.6 lid 1. https://wetten.overheid.nl/BWBR0025458/2020-07-01/0/Hoofdstuk3/Paragraaf1/Artikel3.6/informatie.

Whiting, L. S. (2008). Semi-structured interviews: guidance for novice researchers. *Nursing Standard (through 2013)*, 22(23):35.

Wong, T. H. and Brown, R. R. (2009). The water sensitive city: principles for practice. *Water science and technology*, 60(3):673–682.

Zimmerman, J. B., Mihelcic, J. R., Smith, and James (2008). Global stressors on water quality and quantity.

A

APPENDIX A: PRELIMINARY INTERVIEW TEMPLATE

This appendix contains the preliminary interview template which was used for finding the scope and certain quotes that were taken into consideration in the thesis. This interview was meant as exploration of the topic of the thesis and was unstructured to semi-structured.

1. Introduction

- Consent for recording
- Participation is voluntary based
- Answers will be used for my end-document, but they will be anonymized.
- If a question is not clear, you can ask me for clarification.
- Personal introduction

2. Interview goals

- How is the organization structured?
- What does the decision-making process look like towards implementation of SUDS?
  - re there any specialised departments working actively on the climate change adaptation? Who are the stakeholders (departments/experts)?
  - where are the urban water experts located?
  - what does the process from governasnce towards implementation look like?
  - are there any other parties involved in the drafting phase of a role or governance?
  - How would the responsibilities be divided?
  - Is there any input of external initiatives or other parties?

Public sector

- Have there been innovative solutions that were implemented in the past?
- What kind of innovation? Small or large scaled? o How does the process look from pilot to practice?
- Which steps are required?

- Which parties are involved?
- Which pats are seen as important?
- where are opportunities for pilots found?

Private sector

- Who is responsible for the discharge of rainfall on streets concerning the inhabitants?
- What do you do to inform inhabitants and housing-corporations about their responsibility of discharge of rainwater?
- How do you deal with businesses and firms located at your location?
- Other topics that may be relevant that I haven't talked about which could be interesting?
- Are there any documents that are relevant for my thesis that you could provide?

B

APPENDIX B: LIST OF FRAMEWORKS TAKEN INTO CONSIDERATION

Framework	Author	Topic	Main factors in the method
Policy arrangement model (PAM)	Qiao et al., 2018	Challenges to implementing urban sustainable stormwater management from a governance perspective: A literature review	Describes an overview of the potential barriers based on four categories: - Actors - Resources - Rules of game - Discourses
Policy arrangement model (PAM)	Dang et al., 2016	A framework for assessing governance capacity: an illustration from Vietnam's forestry reforms.	Same as Qiao et al. - Actors & resources - Rules of game - discourses
Adaptive capacity wheel	Gupta et al., 2010	The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society	- Variety - learning capacity - room for autonomous change - leadership - availability of resources - fair governance. These
Four A model	Brown & Farrelly, 2009 RAAK (2020)	Delivering sustainable urban water management: A review of the hurdles we face	- Awareness - Association - Acquisition - Application
-	Nguyen et al., 2018	implementation of a specific urban water management - Sponge City	- Technical and physical challenges - Financial challenges - Legal and regulatory challenges - Public awareness and acceptance
Eight factor + Four-A	Cettner et al., 2014	Assessing receptivity for change in urban stormwater management and contexts for action	1. Quality and coherence of policy 2. Key people leading change 3. Environmental pressure 4. Supportive organizational culture 5. Effective managerial/practitioner relations 6. Cooperative interorganizational networks

			7. Simplicity of goals 8. The fit between the change agenda and the locale
Clusters of barriers	Biesbroek et al., 2013	On the nature of barriers to climate change adaptation	1. Conflicting timescales 2. Substantive, strategic and institutional uncertainty 3. Awareness and communication 4. Institutional crowdedness and institutional voids 5. Motives and willingness to act 6. Fragmentation 7. Resources
Governance Capacity Framework (GCF)	Van Koop et al., 2017	Assessing the Governance Capacity of Cities to Address Challenges of Water, Waste, and Climate Change	- Awareness - Useful knowledge - Continuous learning - Stakeholder engagement - Management ambition - Agents of change - Multi level network / potential - Financial viability - Implementing capacity
Classification according to Adger et al. (2007)	Uittenbroek, Janssen-Jansen & Runhaar (2013)	Mainstreaming climate adaptation into urban planning: overcoming barriers, seizing opportunities and evaluating the results in two Dutch case studies	- Ecological and physical limits - Technological barriers - Financial barriers - Information and cognitive barriers - Social and cultural barriers

C

APPENDIX C: FRAMEWORKS CONSULTED FOR FRAMEWORK

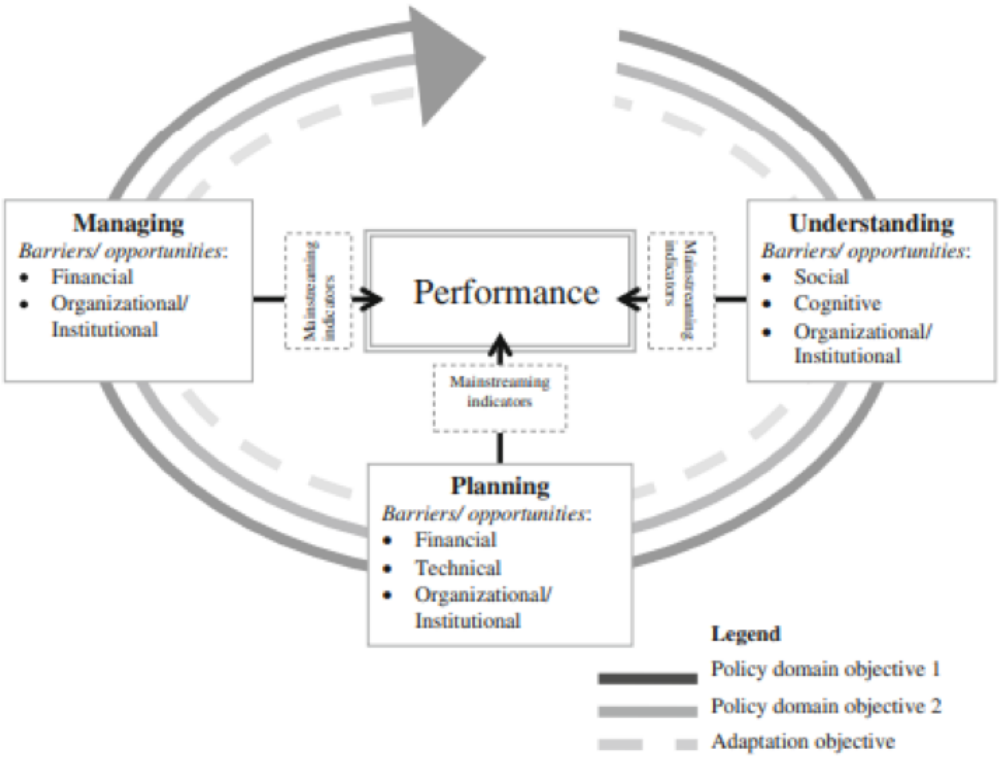

Figure C.1: Policy phases and barriers and opportunities for mainstreaming climate adaptation (Uittenbroek et al., (2013).

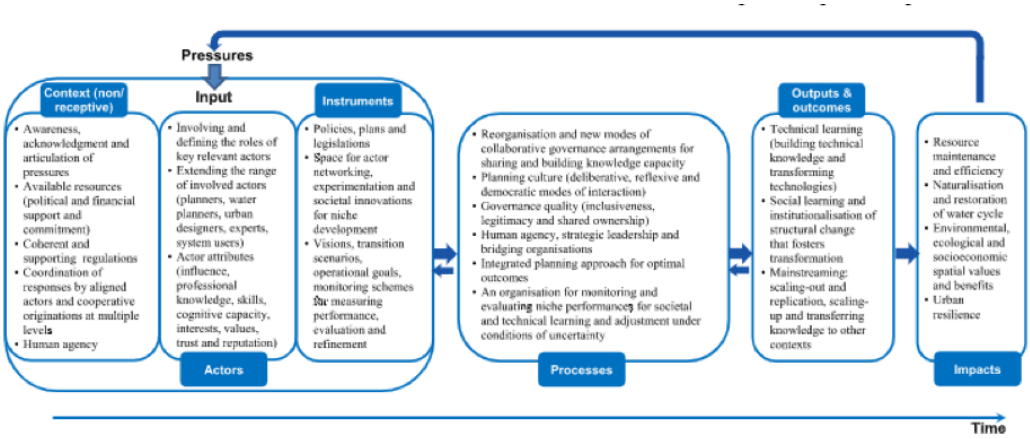

Figure C.2: Methodological framework outlining key factors and aspects to transition for implementation of SUDS (Suleiman, 2020)

Dimensions	Conditions	Indicators
Knowing	1 Awareness	1.1 Community knowledge
		1.2 Local sense of urgency
		1.3 Behavioral internalization
	2 Useful knowledge	2.1 Information availability
		2.2 Information transparency
		2.3 Knowledge cohesion
	3 Continuous learning	3.1 Smart monitoring
		3.2 Evaluation
		3.3 Cross-stakeholder learning
Wanting	4 Stakeholder engagement . process	4.1 Stakeholder inclusiveness
		4.2 Protection of core values
		4.3 Progress and variety of options
	5 Management ambition	5.1 Ambitious and realistic management
		5.2 Discourse embedding
		5.3 Management cohesion
	6 Agents of change	6.1 Entrepreneurial agents
		6.2 Collaborative agents
		6.3 Visionary agents
Enabling	7 Multi-level network. . potential	7.1 Room to manoeuvre
		7.2 Clear division of responsibilities
		7.3 Authority
	8 Financial viability	8.1 Affordability
		8.2 Consumer willingness to pay
		8.3 Financial continuation
	9 Implementing capacity	9.1 Policy instruments
		9.2 Statutory compliance
		9.3 Preparedness

Figure C.3: Chronological order framework (Van Koop et al., 2017)

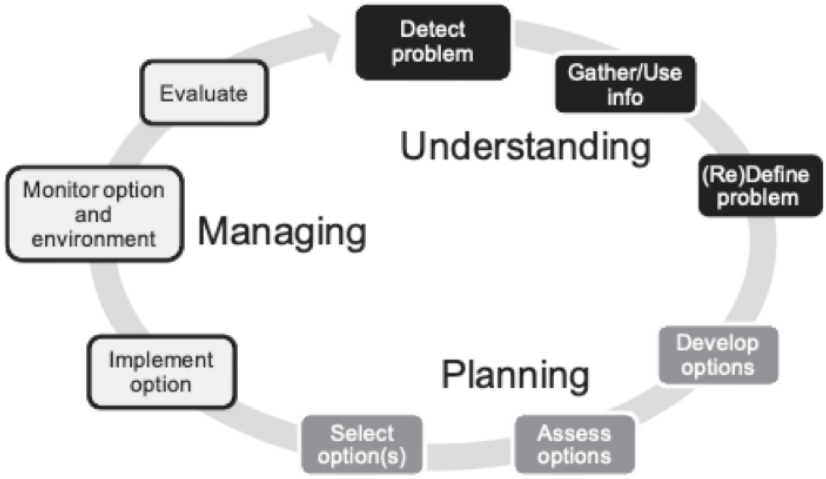

Figure C.4: Phases and sub-phases (Moser and Ekstrom, 2010)

D

APPENDIX D: ELABORATION OF FACTORS INFLUENCING IMPLEMENTATION FOR DRIVERS AND INITIATION PHASE

In this section a brief overview is presented of the factors per phase concerning implementation of SUDS, the frameworks and categories considered are briefly elaborated in Appendix A1. To a certain extent, it is possible do divide the barriers amongst the different phases knowing that some types of barriers may re-occur in different phases under a different context. A limitation that is therefore bound to context is that to a certain level there is subjectivity involved in where certain barriers on where they have to be placed in the process, which can only be learned from iterative studies.

D.1. DRIVERS (LANDSCAPE INFLUENCE ON THE REGIME) AND UNDERSTANDING

Societal and political awareness is considered to be an important condition in literature on climate change adaptation (Biesbroek et al., 2011).

Understanding describes the first phase in the mainstreaming process, barriers and opportunities in this phase are usually related to social, cognitive, organizational and institutional factors (Uittenbroek et al., 2013). Awareness is elaborated by Brown and Farrelly (2009) and Van Koop et al. (2017) as the individual or organization recognizing a problem and the local urgency for a solution.

In more applied terms it implies that there is knowledge and a consciousness of lacking of the current system and the usefulness of application of alternatives (De Graaf et al., 2009; Van Koop et al., 2017). Awareness can span from different kinds of external influences, the PESTEL framework is sometimes used to identify those external barriers (Kielkowsa et al., 2018). The PESTEL structure takes the following factors into consideration: political, economic, social, technological, environmental, and legal. Factors that influence the amount of awareness are communication between science, policy and society, this lack of communication can result in a low level of awareness, high

scepticism, overconfidence or even denial (Biesbroek et al., 2011; Moser, 2009; Van Herk et al., 2011). The recognition and sense of urgency can be formed due to experiences with sewer deterioration, fluvial flooding experiences or by influence of the landscape level (e.g. the National Delta Plan by the government). Internally per sub-component of an organization, information/knowledge should be spread evenly amongst all of those involved for levelling the awareness. The internal barriers in the mostly relate towards social, cognitive and organizational/institutional barriers (Uittenbroek et al., 2013).

Useful knowledge differs from community knowledge in the sense that it is based on interpretation of available data and which helps in decision-making between stakeholders (Van Koop et al., 2017). To understand a problem one first has to become aware through availability and accessibility of information, by interpreting this information one can be activated to take action (Brodnik and Brown, 2017).

It is stated that the factor of knowledge is based on three criteria: information availability, information transparency and knowledge cohesion (Van Koop et al., 2017). Brodnik and Brown (2017) add a fourth factor to this list, which is activation.
In the case of climate adaptation it would relate to the recognition of the magnitude of the water surplus due to increased rainfall and associated sewer capacity, based on a climate stress test usually (Information availability).
This information needs to be shared by effective communication so that all stakeholders can understand and access it, this prevents knowledge gaps and fragmented policies (information transparency). Finally, knowledge cohesion is brought forward which follows from the information transparency, meaning that there is a uniform interpretation of this information. This is backed by Suleiman (2020), which states that for a change in the regime problems have to be solved in integrated manner, so that actors understand each other better. This is a recurring factor which comes back in other phases as-well.
Finally the activation, refers to if the accessible knowledge and information are actually used in a social interaction (Brodnik and Brown, 2017).

D.2. WILLINGNESS

After awareness and understanding is formed, the individual or organization has to associate with the issue in order to become to become responsive.

Barriers concerning willingness to act have only been recently discussed in climate adaptation (Biesbroek et al. 2011; Tompkins et al., 2009). Central in this discussions are psychological attributes of cognitive decision making processes on adaptation, factors such as attitudes, ethical beliefs, norms and value that explain why individuals choose to engage in adaptive behaviour. This phase is successful when behaviour internalization is reached, in a way that when a higher level of knowledge is reached amongst stakeholders this would lead to a change in their behaviour and an increase in their drive and willingness to implement sustainable approaches (Biesbroek et al., 2013; Van Koop et al., 2017). Willingness is described by a few factors which were retrieved through the frameworks in Appendix A1.

Stakeholder engagement is represented in most of the frameworks discussed in the appendix, it

may lead to better problem-framing and solutions that satisfy all parties (Van Koop et al., 2017). This type of engagement requires intensive communication and may require a lot of time, as opposed to not doing it in the starting phase. However, this can be seen as an investment which will be compensated in later stages since less retroactivity will be required The first condition is described as stakeholder inclusiveness, which means the extent to which (representative of) stakeholders are able to voice their opinions and desires. The protection of core values and progress and variety of options, come down to a supportive organizational culture (Cettner et al., 2014). If there are similar core values, different departments may actually share their strivings. And if there is a supporting environment, people would dare to take more risks and be more willing to take work across their designated boundaries and be taking research and innovation into consideration Cettner et al., 2014). Together they provide a higher probability that these desires and wishes are taken into consideration, furthermore they ensure that there is transparency and a trustful environment within the decision making process.

Management and policy ambition are a measure of how sustainable management is perceived within the policies or action taken by institutions. Management ambitions are assessed by ambitious and realistic management, discourses and management cohesion (Van Koop et al., 2017; Cettner et al., 2014). The first term is mainly related to having realistic goals, which are described as: long term goals with intermittent measurable targets, that are all provided with sufficient resources and flexible mechanisms to respond to changing situations. In addition, these goals need to be rather simplistic and there should be an awareness on the priorities of different departments.
These goals may be interpreted as the full organization, or as goals which different departments within the organization have.

The third part of this condition takes into consideration discourses which could be having an impact on the management of SUDS and their implementation policies. Management policy cohesion takes into consideration the level of integration between different policies and strategies across different sectors, governance levels and intra-organizational.

Agents of change A transition within the regime can't happen without human involvement and representation, pressures do not affect the regime itself, but the human actors which need to translate the theory to practice (Suleiman, 2020).

Agents of change refers to the intrinsic motivation of people and their willingness to take risks, and the support given to those efforts to change current approaches to more decentralized systems. The concept is not limited to people in leading positions, but involves all actors that part take into the practices concerning the current inertia (Van Koop et al., 2017). Important actor attributes listed by Suleiman (2020) consist of influential power, professional knowledge, skills, interest and trust. Van Koop et al. (2017) lists three different agents which fulfill these attributes: entrepreneurial agents, collaborative agents and visionary agents. The entrepreneurial agents have the means and skills to gain access to resources, seek opportunities and manage risks, they are also described as the key people that are leading change (Cettner et al., 2014). The collaborative agents enable the formation of cooperation between different actors. Visionary agents envision long-term adaptive approaches and are able to steer current policies and actions into that direction.

What this list of actors still lacks is the involvement of relevant actors, multiple studies have shown that it is important to take the water cycle into consideration in the spatial-planning process, hence people that have expertise in this field should be involved in this process (Suleiman, 2020).

D.3. ENABLING

When the behaviour internalization is reached and actors/departments within the organization are open to adaptation, there needs to be a capacity that enables this transition. This depends form of capacity depends on three factors: Multi-level network potential, financial viability, implementing capacity. Besides the capacity, the skills related to the negotiation, communication and application are crucial factors in this phase aswell (Brodnik and Brown, 2017; Raak, 2018)
Multi-level network potential is described by van Koop et al. (2017), according to this condition networks are vital in dealing with governance challenges, stakeholders at different levels and have different motives. Hence, there needs to be room to manoeuvre in such way that there is an opportunity to implement climate adaptive measures by collaboration within networks. A clear division of responsibilities emphasizes which actors are responsible for which tasks (e.g. climate adaptation, rainfall drainage), authority means that there is a form of regulation or policies that promotes the requirement to work on implementation of SUDS.

Financial Viability is characterized by affordability, willingness to pay and financial continuation (Van Koop et al., 2017). The affordability is based on the budget allowed by the municipalities, together with the willingness to pay these two form an important factor in the implementation these form the base. Asides from the costs that are initially made, there are different costs under financial continuation which revolve around long-term strategies (i.e. replacement due to new innovations or maintenance).

Implementing capacity is described by policy instruments on regime or landscape level, which can either hamper of promote implementation of SUDS. This is supported by another factor: the fit between the change- and locale agenda or conflicting time scales (Biesbroek et al., 2013, Van Koop et al., 2017). The long-term changes in a climate system and the rate of projected and observed impacts are difficult to relate to the dynamics of societal changes, particularly the short-term perspective in decion-making policies (Adger et al, 2009). If there is competition between both agendas , a limited amount of attention would be paid to long-term issue, thus making it difficult to mainstream adaptation into new and existing policies (Biesbroek et al., 2011).

Self-reinforcing Mechanisms Uittenbroek (2016), describes four self-reinforcing mechanisms that are applicable to the adaptation of SUDS through municipalities, they are part of the barriers that apply to mainstreaming climate adaptation. A short overview of how they work is provided in this section.

- Complementary effects is the product combining resources or practices within routines to become more efficient (Uittenbroek, 2016). Costs and time can be saved, examples would be that when a road is opened for maintenance, the sewers can be inspected. Adding in crates would require different insights, a different schedule of time, which could contradict the synergy. The new synergy that is built should therefore be considered better than the previous one by those involved in the process.

- Coordination effects means that different parties within the organisation start being able to predict each other's moves, for which they can start anticipating. In time, these routines start becoming the norm and become fit into place. When climate change does not fit into the role of those involved within the coordination, it may become a problem for mainstreaming.

- Learning effects are formed when actors become more familiar with their routines and apply small iterations to optimize this routine, deviating from this routine may than become tough.

- Adaptive expectation effects are based on the idea of preferences of actors not genuine, as they are based on expectations of other actors to fit in. It is that actors adjust their preferences in order to gain support by their peers for their actions. Hence, their false actions may be unjustified as they are based on what their colleagues might think.

E

APPENDIX E: CROSS-CASE METHODS OF CASE SELECTION AND ANALYSIS

Cross-Case Methods of Case Selection and Analysis

Method	Definition	Large-*N* technique	Use	Representativeness
Typical	Cases (one or more) are typical examples of some cross-case relationship.	A low-residual case (on-lier)	Confirmatory; to probe causal mechanisms that may either confirm or disconfirm a given theory	By definition, the typical case is representative, given the specified relationship.
Diverse	Cases (two or more) exemplify diverse values of *X*, *Y*, or *X/Y*.	Diversity may be calculated by (1) categorical values of *X* or *Y* (e.g., Jewish, Catholic, Protestant), (2) standard deviations of *X* or *Y* (if continuous), or (3) combinations of values (e.g., based on cross tabulations, factor analysis, or discriminant analysis)	Exploratory or confirmatory; illuminates the full range of variation on *X*, *Y*, or *X/Y*	Diverse cases are likely to be representative in the minimal sense of representing the full variation of the population. (Of course, they may not mirror the distribution of that variation in the population.)
Extreme	Cases (one or more) exemplify extreme or unusual values of *X* or *Y* relative to some univariate distribution.	A case lying many standard deviations away from the mean of *X* or *Y*	Exploratory; open-ended probe of *X* or *Y*	Achievable only in comparison with a larger sample of cases.
Deviant	Cases (one or more) deviate from some cross-case relationship.	A high-residual case (outlier)	Exploratory or confirmatory; to probe new explanations for *Y*, to disconfirm a deterministic argument, or to confirm an existing explanation (rare)	After the case study is conducted, it may be corroborated by a cross-case test, which includes a general hypothesis (a new variable) based on the case study research. If the case is now an on-lier, it may be considered representative of the new relationship.
Influential	Cases (one or more) with influential configurations of the independent variables.	Hat matrix or Cook's distance	Confirmatory; to double-check cases that influence the results of a cross-case analysis	An influential case is typically not representative. If it were typical of the sample as a whole, it would not have unusual influence on estimates of the overall relationship.

(continued)

Figure E.1: Cross-case methods of case selection and analysis Source: John Gerring (2008)

F

Appendix F: Interview template overview case studies

Terms and conditions of the interview

- Do you give consent for the recording of this interview?
- Do you agree that your participation is voluntary based?
- Your input will be used in my thesis document which will be posted in the repository of the TU Delft (and likely VP Delta)
- Your answers will be anonymized, your function will still be clear
- If a question is not clear please ask me for clarification.
- A personal introduction, study, research objective and methodology, purpose of interview.

Introduction

- Which organisation do you work for and what is the role you fulfil in this organisation?
- What was your role within the project?

Drivers

- Which drivers do you see in your city, which of them were important for the project?
- Which city goals or policy domains are related towards the implementation of suds/climate adaptation?
  - Living & environment, economy, sustainability, social-cohesion, health and wellbeing, infrastructure, water etc?
- Do you reckon that the drivers have changed in time?
- Do you reckon that the influence of the drivers has changed in time?
- Has there been any complaints in the past in Spangen/Capelle about pluvial flooding?
- How important were the neighbourhood communities in the implementation?

Understanding/Information

- What does your department look like structure wise?
  - How many people do you operate with on the daily
  - How are SUDS perceived within your department
  - How often is there discussion with other departments
  - Is it hard to persuade other departments of your beliefs concerning SUDS?
- How much knowledge is there available within your department about SUDS?
- Was there anyone that had a good indication of the reliability of the technology or proper knowledge?
- How is the past experience from your point of view about SUDS?
- Is there any horizontal connectivity concerning SUDS within the organization?
- Are there any opportunities for education about SUDS?
- Was there any relation between private, societal parties and the involved departments at the municipality?

Willingness

- Do you find that when ideas that are out of the box are introduced, that they are well received by project teams?
- Do you think that people are well receptive to ideas that are out of the box, or would they rather stick to the conventional methods?
- Overall was there a good supportive culture when this concept was introduced?
- Were there any other alternative solutions concerned for this problem?
- Is the management within the organization realistic or too ambitious?
- Were there any discourse (scepticism) given SUDS within your department?
- Would you say that there are many people within your organisation that strive for the long-term goals and even when they're not in a management position propose different ideas?

Capacity

- How flexible are the laws, regulations and permits concerning innovative projects? How was that for the implementation of this specific project?
- How good is the network with potential other stakeholders/organizations that are involved? Was there any hiccups setting up the communication and finding the right people? How readily were they willing to help?
- Do you think there are enough financial resources available towards implementation or pilots? And for this specific project?
- Do you/does your department think these costs were justified?
- Were there any time constraints?

Planning

- how was the location of implementation determined?
- How was this paired with current goals?
- To what extent were the external stakeholders and their input taken into consideration?
- How well was the design paired with current goals?

Managing

Execution

- How involved were the parties of earlier phases in this phase?
- Was the execution as the project team expected?
- Were there any unexpected costs?
- Were there any other unexpected factors?

Maintenance

- Were there any unexpected costs?
- Has the lifecycle of the construction been taken into consideration (from cradle to grave)?
- Who was going to do the maintenance and monitoring, was it hard to establish this looking back?
- Who came up with the maintenance strategy?

Evaluation

- Do you think there is upscaling potential, in the short-term? Why/why not
- If the funding was taken away, would you still think so?
- How consistent do you think this development will stay?
- On what timescale do you see a transition happening where piped systems and decentralized systems will be responsible for the same amount of fluxes?
- How did the investments compare to if you had done it with the different alternatives?

Extra questions:

- Are there any things I've asked but could be important factors to take into consideration for my research?
- Are there any people within the network that I do not have on this interview list which could be important to speak to?

G

APPENDIX G: INTERVIEW CODES

The transcriptions of the interviews conducted with different people from the municipalities of Rotterdam and Capelle have been coded using atlas-TI. The codes of the interviews were added together within the table presented below, they were grouped per phase based on their factor type and sub-phases. The colours green and red respectively indicate the drivers and barriers found in the interviews. The yellow codes indicate advise by the interviewees and codes that cannot be placed grouped in drivers or barriers given the circumstances.

a

a

a

a

a

a

H

Appendix H: Focus group

Terms and conditions of the focus group

- Do you give consent for the recording of this teams session?
- Do you agree that your participation is voluntary based?
- Your input will be used in my thesis document which will be posted in the repository of the TU Delft (and likely on the website of VP Delta).
- Your answers will be processed anonymous into the document, your function sans organisation will still be clear.
- If a question is not clear please ask me for clarification.
- A personal introduction, study, research objective and methodology, purpose of interview.

The objective of this focus group:

"Observing how the findings of the case studies compare to experiences of other municipalities"

Introduction of each participant: Name, function and experience

General questions

- How is the sustainability thinking concerning climate change within your municipality stimulated? (Initiatives, strategies, cooperation's, policy, bottom-up)?
  - where has this orginated from?
- Is there enough budget for SUDS within your municipality? And how important is subsidy?
  - Where is the budget located within the organization?
  - Which budget is specifically used for innovation? GRP or sustainability?
- Would you say that risk management is important for the choice of innovations? If so, in which manner?
  - Do earlier proven technologies have the preference or those of the same type? Or has there been a choice for a completely new innovation.

Policy execution level

- Which parties are responsible for the implementation process within your municipality and what do they do?

  - what are the sizes of these departments?
  - which parties are they within SB?
- How do these departments perceive implementation of SUDS?
  - Do they actively introduce these concepts?
  - Which parties are supportive?
  - Where do differences stem from?
- How does the cooperation work between those departments? Are they well attuned to each other? Where is improvement possible? Is de-compartmentalization required?
  - do most people know each other or does a network have to be created?
  - Is it easy to get into contact wiit hthe right people within the departments? Also as external party?
  - Are there any employees that work as boundary spanners? If so, what do they do that is of importance for your municipality?
- Do you think that there is a demand for more technical expertise within your municipalities concerning climate resilience? Is more knowledge needed or more colleagues?
  - do you guys usually hire an external consultancy for innovations?
- Do you feel that the pressure on workers has increased the past few years due to the budgeting of the government?

Future

- From national policies (National Deltaplan 2019 and Bestuurdakkoord 2018), space is made for stresstests, strategies, risk dialogues and speeding up of implementation for pioneers through extra budget
  - Has your municipality applied for this subsidy or is there a plan to use it?
  - How does this translate to practice?
- Does your municipality work together with other municipalities?
- Would external schooling like in the business sector be a interesting for municipalities?
- On which terms do you see adaptation and standardisation increase within municipalities?
- In which time span do you see this happening?