Paving the Way

Exploring the Potential of Green Parking and Collaborative Information Sharing between Municipalities and Companies

by

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Preface

This thesis marks the end of my journey as a civil engineering student in Delft. Although the road has not always been easy, I am grateful for the lessons I learned along the way.

I want to thank the thesis committee sincerely. First, Erik, for helping me formulate the initial research aim and guiding me throughout the process. Hans, for offering feedback throughout the process and for using your vast network to connect me with insightful organizations, companies, and people. Emilie and later Robert of VP Delta+ for providing feedback and helping me find numerous interviewees. I would also like to thank all interviewees for participating in my research. Your openness and time have made this thesis possible. I hope that reading this thesis will provide you with valuable recommendations to aid in the widespread implementation of innovations, specifically green parking. Special thanks go out to Sem van Velsen for providing me with insights and feedback from start to finish.

Lastly, I would like to thank my girlfriend, Kalina, for reviewing this thesis with me.

I hope this thesis *paves* the way to a *greener* future.

Den Haag, June 5th 2023

Abstract

Changes in the climate have forced municipalities to rethink urban development and become more climate-resilient. One way they can achieve this is by implementing Sustainable Urban Drainage Systems, or SUDS. Permeable pavements are a type of SUDS designed to let rainwater infiltrate, thereby reducing runoff and lowering peak flows. They can be used to mitigate climate change effects.

Municipalities have slowly started implementing permeable pavements into their projects on a small scale, but numerous barriers still stand in the way of widespread implementation. Various barriers are related to information sharing. This thesis aimed to improve the innovation implementation process by examining information sharing between municipalities and companies. Grass concrete pavements, or green parking, was chosen as a case study, a relatively new permeable pavement system using open pavers, substrate, and a mix of grass seeds to allow precipitation to infiltrate while adding green to urban areas.

Three main flows of information were considered: between companies and municipalities, between different departments within the same municipality, and between municipalities and other levels of government. Interviews were conducted with interviewees in various roles from both companies and municipalities involved in the process of innovation implementation. A network of various factors was formed, with three key issues:

- A lack of consensus on what a successful project should be.
- Uncertainty about responsibility leading to a situation where the implementation of green parking is dependent on the motivation of individuals.
- Pilot projects are conducted by municipalities without clear goals, therefore, producing no results that can be analyzed or used for upscaling.

The second part of the thesis involved further analysis of the three key issues. Multiple recommendations for municipalities and companies were formulated. Recommendations for conducting successful pilot projects are also provided and are applicable to both green parking as well as other innovations.

For municipalities, the recommendations are to make responsibilities clear, perform a life cycle cost analysis, set clear and concrete goals in their climate adaptation strategy, share successful experiences, and create a step-by-step guide for innovations to become standardized. These recommendations are mainly aimed at green parking but will also benefit the implementation of other innovations.

For companies, the recommendations are to create realistic expectations, convince the water board of the water storage capacity of the system, and conduct further research into optimizing maintenance plans. These recommendations are mainly aimed at green parking and Sustainable Urban Drainage Systems (SUDS).

For pilot projects, the recommendations are to reach a consensus on what defines a success beforehand, set realistic goals and start small, include a follow-up plan, find partner municipalities to collaborate with, and find a balance between intensive and superficial monitoring.

The results from this thesis consisted of concrete recommendations for both municipalities and companies to improve the innovation implementation process. Furthermore, the results can be a starting point for more profound research into information sharing and how it relates to innovation implementation. This can include testing the recommendations at a municipality to optimize the process, like setting up a pilot program or expanding the climate adaptation strategy.

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List of Acronyms

BGI Blue-Green Infrastructure
BMP Best Management Practices
CoP Community of Practice
DPSA Delta Plan on Spatial Adaptation (Deltaplan Ruimtelijke Adaptatie)
GRP Gemeentelijk Rioleringsplan (Municipal Sewage Plan)
HOR Handboek Openbare Ruimte
HIOR Handboek Inrichting Openbare Ruimte
KAN Klimaatadaptief bouwen met de natuur (Climate-adaptive building with nature)
LID Low-Impact Development
LIOR Leidraad Inrichting Openbare Ruimte
MKI Milieukostenindicator (Environmental Cost Indicator)
MLP Multi-Level Perspective
NBS Nature-Based Solutions
PA Porous Asphalt
PC Porous Concrete
PPs Porous Pavers
PPSs Permeable Pavement Systems
PICPs Permeable Interlocking Concrete Pavers
SC Sponge City
SUDS Sustainable Urban Drainage Systems
TRLs Technology Readiness Levels
WSUD Water Sensitive Urban Design

1

Introduction

The world is currently facing a changing climate that affects weather extremes around the globe and impacts economies, human health, and ecosystems (Masson-Delmotte et al., 2021). For example, extreme rainfall events lead to an increased risk of pluvial (urban) flooding (Costa et al., 2021). Pluvial flooding occurs when a high-intensity rainfall event exceeds the sewer system's drainage capacity, leading to water being unable to drain away from the street. Increased urbanization, meaning more 'gray' of impermeable areas and less water infiltrating into the ground, combined with sewer systems not designed with climate change in mind (Sušnik et al., 2014) will lead to an increased risk of pluvial flooding in the future.

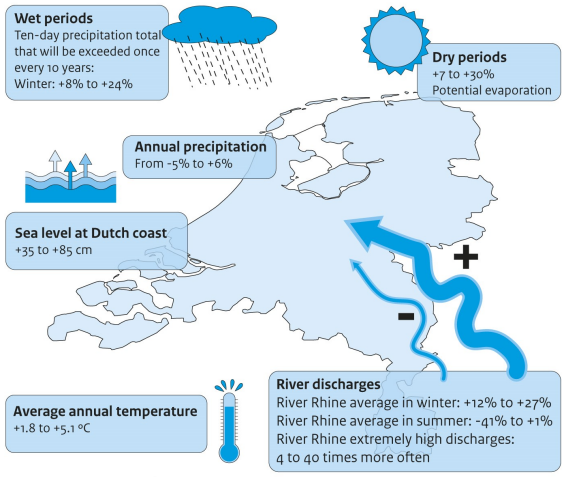

Figure 1.1: Possible climate changes for 2100 (Ligtvoet et al., 2022)

Drier summers have already had a severe economic impact. For example, in the summer of 2018, droughts caused an estimated damage of between 900 and 1650 million euros in the Netherlands (van de Velde et al., 2019). Part of the damage was due to soil subsidence caused by the lack of rain.

Another issue is the rising temperature, which will lead to heat stress issues, especially in urban environments (Koop et al., 2017). By 2050, the number of 'summery' days, meaning temperatures exceeding 25 degrees Celsius, will increase by 13% (KNMI, 2014). Higher temperatures negatively influence public health, leading to uncomfortable living conditions in the summer in urbanized areas and an increase in heat-related mortality (Deely et al., 2020; Kleerekoper et al., 2012).

1.1. Problem Statement

The projected changes in the climate have led to several government programs, one of which is the Delta Programme, a yearly proposal by the Delta Commissioner related to flood risk management, freshwater availability, and spatial adaptation (Habers, 2022a). It is written in collaboration between the different levels of government—the national government, provinces, water boards, and municipalities—and businesses (Delta Programme Commissioner, 2022). In 2017, as part of the Delta Programme, the Delta Plan on Spatial Adaptation (Deltaplan Ruimtelijke Adaptatie) (DPSA) was established to make the Netherlands climate-resilient and water-robust by 2050. One of the intermediate goals was to always act in a climate-proof way by 2020, but this goal has not been successful and has seen limited implementation (Delta Programme Commissioner, 2022).

In a letter to Parliament, the Ministry of Infrastructure and Water Management recently stressed the importance of healthy soils and water in the Netherlands. The letter stated that a government goal will be to use the land as efficiently as possible and to use impermeable materials as little as possible so that more rain will infiltrate into the soil (Habers, 2022b). For municipalities, this new focus on healthy soils and water, as well as project changes in precipitation are especially relevant since—according to the Water Act—they (the municipal council and the municipal executive) are responsible for collecting and disposing of rainwater runoff and precluding or limiting negative influences caused by the groundwater level (Water Act section 3.5, 2022; Water Act section 3.6, 2022).

To become climate-resilient and water-robust by 2050 under the Delta Programme, the different levels of Dutch government can choose to implement innovations into their projects instead of relying on current methods and technologies. A variety of different innovative products aimed at mitigating climate change exists. Many innovative products are related to urban water management and therefore have municipalities as their main client.

Innovations aiming to mitigate the effects of climate change in urban areas exist under several different names. Some of the most-used ones are Sustainable Urban Drainage Systems (SUDS), Blue-Green Infrastructure (BGI), or Nature-Based Solutions (NBS). Even though other terms are used, the aim of these innovations is the same: to combine (urban) water management with green infrastructure (Langergraber et al., 2021; Liu et al., 2019). This thesis will use the term SUDS (sometimes spelled SuDS, omitting the 'urban' part of SUDS) for clarity and consistency. SUDS are particularly interesting for municipalities due to their obligations outlined in the Water Act and the previously mentioned changes in the climate.

One product type within the broader definition of SUDS is permeable pavements. These pavements are designed to let rainwater infiltrate, lowering peak flows and runoff rates (Boogaard et al., 2014). First used in the early 1970s in the USA and in 1997 in the Netherlands, permeable pavements are a relatively old innovation (Beenen and Boogaard, 2007; Thelen, 1972).

Since then, numerous types of permeable pavements have been developed using a wide range of materials, such as asphalt and various kinds of pavers (Kayhanian et al., 2015). Despite this, permeable pavements in the Netherlands have seen limited use outside small-scale projects (de Graaf-van Dinther et al., 2021). There are still a lot of barriers standing in the way of the broader implementation of SUDS and, more specifically, permeable pavements. These barriers are often interlinked and vary in importance depending on the project.

An obvious barrier to implementation is financial, meaning that SUDS are more expensive than traditional 'gray' infrastructure. Previous research on the financial barrier mentions the lack of willingness to invest in SUDS because of higher investment costs (Johns, 2019; Keeley et al., 2013; Lin et al., 2019). Another factor is maintenance. Since SUDS are relatively new and not as widespread as gray infrastructure, maintenance costs are uncertain because SUDS often do not fit in with current maintenance plans (Deely et al., 2020; Thorne et al., 2018).

Inertia is another barrier. To fit SUDS into urban development and planning requires changing routines and methods that have existed for a long time. It also requires different departments within municipalities to be willing to change. This has been cited as a major barrier (Cettner et al., 2014; Deely et al., 2020; R. De Graaf et al., 2009; Suleiman, 2021).

Additionally, several issues regarding the implementation of innovations relate to information sharing. This includes information sharing between companies selling innovations and municipalities and internal information sharing between different municipal departments.

This information gap can affect innovation implementation in multiple ways. (Wihlborg et al., 2019) stresses the importance of knowledge about SUDS within municipalities and maintaining contact between different departments. (Koop et al., 2017) and (Biesbroek et al., 2011) mention the fragmentation and diffusing of information and communication between and within organizations as a major barrier to the implementation of new products or policies that deal with climate change. Specifically, a lack of communication between stakeholders can result in skepticism, overconfidence, or even denial (Biesbroek et al., 2011).

Another issue related to information is the lack of technical knowledge. This is especially relevant for permeable pavements. The lack of knowledge mainly concerns the long-term effectiveness, life cycle costs, and how local variables—soil, traffic intensity, groundwater levels—influence how the system works (de Graaf-van Dinther et al., 2021). This lack of knowledge was recognized as a significant factor in the decision whether or not to implement permeable pavements (R. De Graaf et al., 2011). Although there has been some research into the long-term effectiveness of permeable pavements (Boogaard et al., 2014; Boogaard and Lucke, 2019; Kayhanian et al., 2015), municipalities remain hesitant to implement them on a bigger scale.

This thesis will focus on the information gap. Information sharing between municipalities and companies and internal information sharing between different departments within the municipality will be addressed. The goal is to find strengths and weaknesses and develop recommendations. The topic will be explored through a case study: permeable pavements. Specifically, one type of permeable pavement, grass concrete pavement. This relatively new permeable pavement consists of grass growing through gaps in mainly concrete pavers.

It goes by many different names: green pavements, grass block pavers, and grass concrete pavements, to name a few. This thesis will use the term ‘green parking,’ a direct translation from the Dutch ‘groen parkeren,’ for clarity and consistency. The case study was chosen based on preliminary meetings with the supervisors as well as through personal communication, where it was found that there was significant difficulty in implementing green parking, but the exact barriers were unclear.

1.2. Research Aim

This thesis aims to address the information gap. Information sharing between municipalities and companies and internal information sharing between different departments within municipalities will be studied. The goal is to find strengths and weaknesses and develop recommendations.

To achieve this, the following research aim is formulated:

This thesis aims to improve the process of innovation implementation by examining information sharing between municipalities and companies, focusing specifically on green parking.

1.3. Research Structure

This thesis is structured according to the Double Diamond structure, a process model developed by the Design Council (Knuth, 2019). The thesis consists of two 'Diamonds' or main phases: the problem and solution phases. Each phase consists of two sub-parts, which can be found in Figure 1.2, indicated by the numbers one through four. Structuring the thesis in this manner allows for the broadening or narrowing of the scope in various parts of the thesis. For example, since the key factors and actors are not known at the start of the research, the first phase aims to find the problems. The second phase will focus on a critical issue and seek solutions and recommendations.

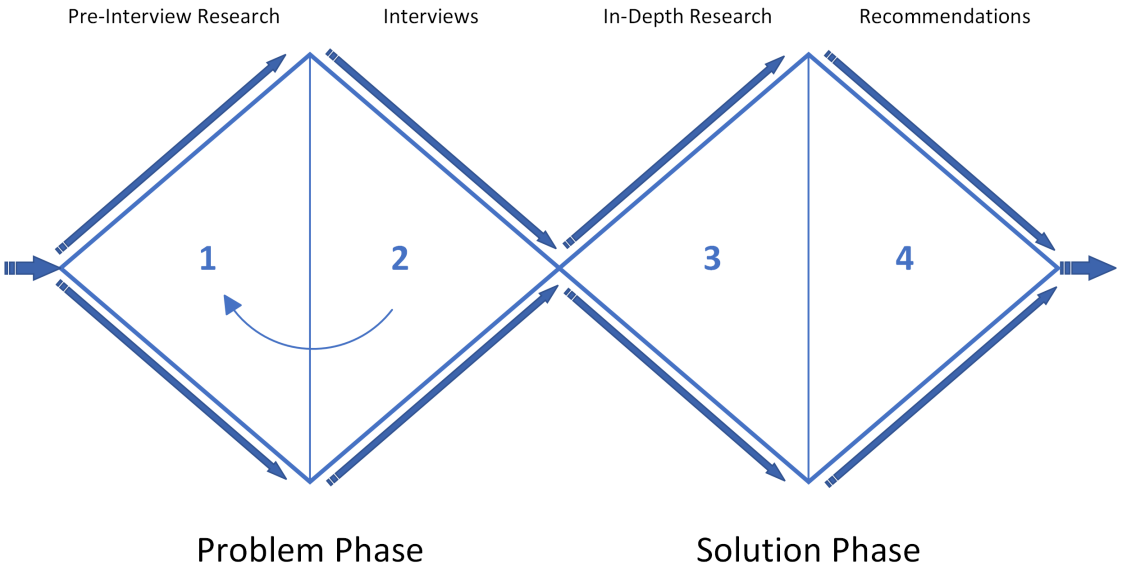

Figure 1.2: Research structure: Double Diamond Model

The first part of the thesis involves a literature review and document analysis. The goal is to get more familiar with the background information and to prepare for the interviews. This will also help in the process of determining key actors and factors to prepare for interviews and to decide whom to interview. In addition, document analysis is done to improve the knowledge of the current situation regarding information sharing.

The second part of the thesis involves interviews with the key actors found in part one. New insights regarding potential interviewees or documents to analyze might mean moving back to part one of the thesis, hence the arrow in Figure 1.2.

After the second part is finished, a key issue is selected to focus on during part three. Throughout part three, this key issue is studied further.

Finally, part 4 consists of synthesizing all the results from the previous three parts into concrete recommendations for involved stakeholders.

1.4. Research Questions

To achieve the research aim, the main research question is:

What steps can be taken to improve information sharing between municipalities and companies to expand the implementation of innovations, specifically green parking?

To better answer the main research question, multiple sub-questions are formulated. These sub-questions follow the research structure introduced in Section 1.3, so they are divided into two parts. The first half of the thesis focuses on the following sub-questions:

1.1 What kind of information on green parking is currently available to municipalities, where is this information found, and in what form?

1.2 Who/what are the key actors/factors involved in implementing innovations, and how does this process currently happen?

1.3 What is currently missing from available information on innovations in general and green parking specifically?

1.4 What are the main differences between municipalities regarding the current state of implementation of innovations, and what role does information have in this process?

The second half of the thesis addresses the following sub-questions:

2.1 What is the current situation regarding pilots executed by municipalities?

2.2 What makes a pilot a success or failure?

2.3 Who is involved in pilots executed by municipalities?

2.4 What is needed for pilots to become streamlined so the implementation of innovations is improved?

2.5 How can results and experiences be shared between municipalities and other stakeholders?

1.5. Scope

The main subject of this thesis is the implementation of innovations. Since this is too broad to fit into one thesis, multiple scope limitations must be applied:

- The focus will only be on innovation implementation in the Netherlands.
- Only municipalities will be considered. The national government or water boards might be considered when relevant to the implementation of innovations by municipalities.
- Only green parking will be studied in this thesis as an example of an innovation. Other innovative products are only considered or looked at when relevant to implementing green parking.

1.6. Reading Guide

Chapter 2 introduces relevant literature. Next, in Chapter 3, the research process and methods are introduced and explained. After that, in Chapter 4, the results from the interviews conducted during the problem phase will be discussed and analyzed. Chapter 5 discusses the results from the interviews conducted in the solution phase and analyzes them. Next, Chapter 6 presents a discussion, and lastly, Chapter 7 gives a conclusion, and Chapter 8 gives recommendations.

2

Literature Review

This chapter reviews and discusses relevant literature on several topics related to information sharing in innovation implementation. This review serves to get a deeper understanding of the topic and as a basis for the interviews.

The first topic for the literature review is SUDS terminology, history, and examples. This is introduced in Section 2.1. Next, Section 2.2 discusses different types of permeable pavement, including green parking. Subsequently, in Section 2.3, pilots are addressed. In Section 2.4.1, transition management and the role information has in this process are explained. After that, in Section 2.5, municipal climate adaptation strategies are considered. Lastly, Section 2.6 concludes the literature review with the most relevant findings and conclusions.

The topics are picked based on different criteria. SUDS and green parking are researched to gain knowledge and identify possible gaps in the literature. In addition, pilots are studied to help with the solution phase of the thesis. Finally, transition management is researched to aid with the interview process and to add to and amplify the conclusions and recommendations.

2.1. Sustainable Urban Drainage

2.1.1. Terminology

Section 1.1 briefly mentioned the different terms used for innovations in urban water management. As stated before, the term SUDS will be used in this thesis since it is the most used term in Europe. Various terms are used throughout the world to describe similar products or systems. Some of them are mentioned in Section 1.1 (BGI, NBS), others include Water Sensitive Urban Design (WSUD), Low-Impact Development (LID), Best Management Practices (BMP) and Sponge City (SC).

Figure 2.1 gives an overview of the use of different terms and their popularity over time by looking at the number of citations each term has in published literature. Although this figure does not show every possible term, not all terms are widely used. The figure shows an apparent increase in overall usage of all terms related to SUDS, indicating that interest in SUDS has increased worldwide.

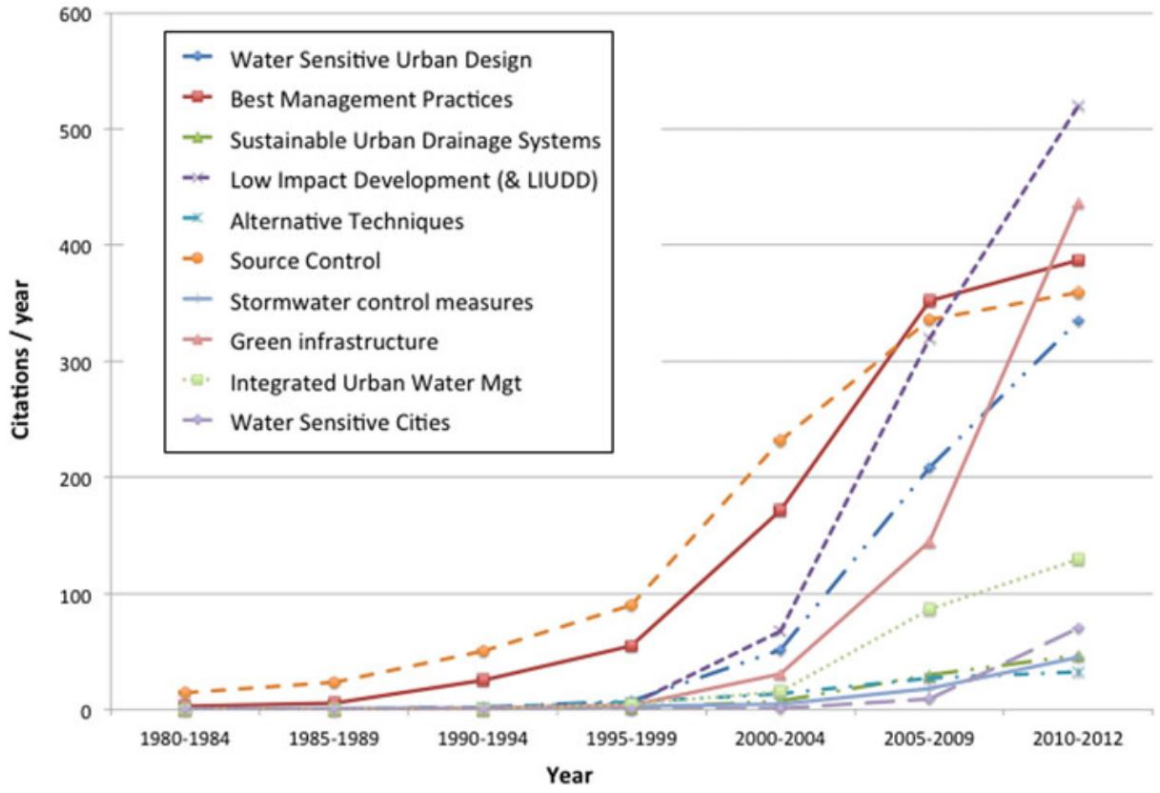

Figure 2.1: Use of different terms related to urban water management over time (Fletcher et al., 2015)

2.1.2. Origins and Goals

Dealing with urban water issues is not new and originated in ancient times (Charlesworth and Booth, 2016). Until recently, most urban water drainage consisted of systems based on pipes to deal with stormwater; these systems were first introduced in London in the 1850s (Scholz and Grabowiecki, 2007). However, aging infrastructure and increased pluvial floods caused by climate change stressed the need for new practices, approaches, and a shift away from piped systems (Cettner et al., 2012).

Initially, the primary function and goal for SUDS was flood mitigation (Imran et al., 2013). This involves collection, storage, optional treatment, and reuse of stormwater. As interest in SUDS and other related terms grew (Figure 2.1), more goals and functions became associated with these terms (Roy et al., 2008), as seen in Figure 2.2. In the period 1960-2013, several new themes and topics were introduced as SUDS. Overtime biodiversity, increased green areas in urban environments, water quality, and most recently, urban temperatures were addressed using SUDS. For example, systems developed with multiple functions and goals in mind, combining heat and water issues, have also increased in recent decades (Fletcher et al., 2015).

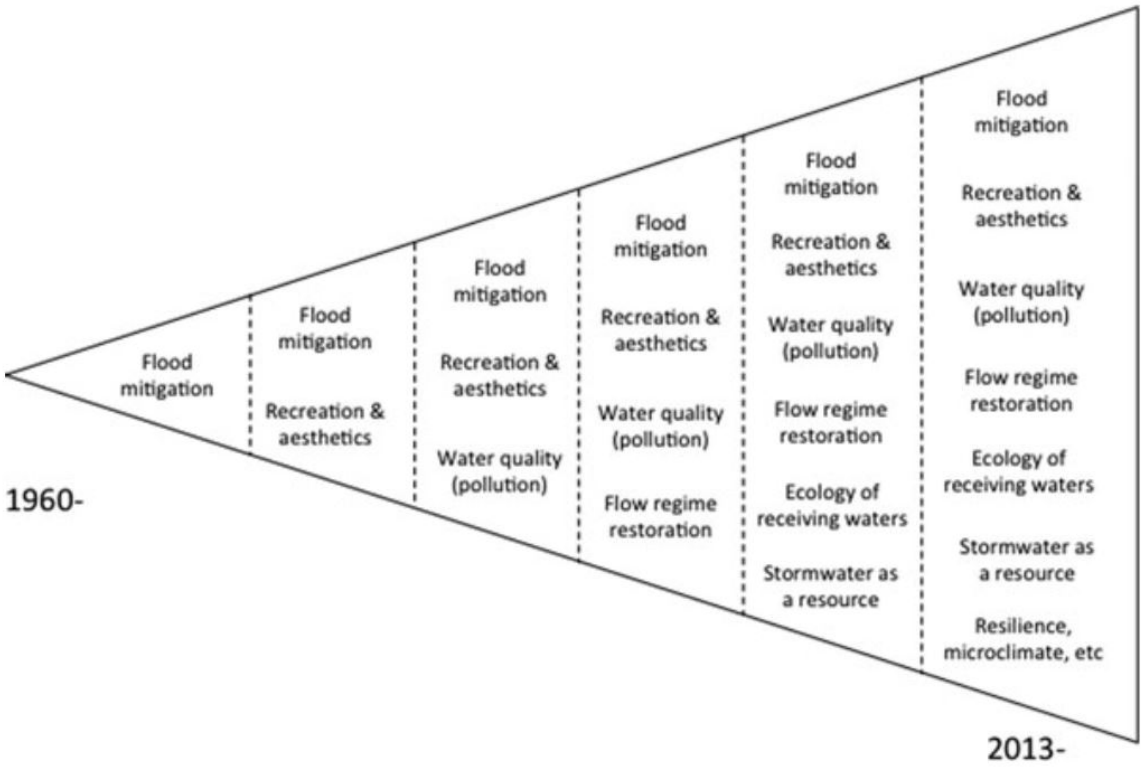

Figure 2.2: Topics and themes included in urban water management from 1960 to 2013 (Fletcher et al., 2015)

2.1.3. Categorization

SUDS can be categorized in multiple ways and the categorization has changed over the years to include new topics and terms, as was seen in 2.1.2 and Figure 2.2. For example, categorization can be done based on the main goal (flood control, heat stress, water quality, etc.) or the location of the implemented technology. Other literature makes a further distinction based on added technology or innovative products and the presence and type of greenery (Arahuetes and Olcina Cantos, 2019; Castellar et al., 2021; Langergraber et al., 2021).

Another way is to categorize SUDS based on the hydrological water cycle (Liu et al., 2019, Qiao et al., 2019):

- On-site control: Small-scale solutions like green roofs (Figure 2.3) or infiltration crates (Figure 2.4) to retain water locally. Permeable pavements and green parking also fall within this category.
- Process control: Solutions based either on a delayed flow or retaining the water locally. One example is Bioswales (Figure 2.3), which consists of a shallow pit or channel in urban areas designed to act as water storage and can also improve water quality (Xiao et al., 2017). Water is infiltrated into the soil or slowly discharged into the sewer system via drainage pipes (Wentink, 2021).
- Downstream control: Examples of downstream control SUDS are dry basins or wetlands. These solutions aim to prevent floods by storing water and slowly discharging it.

Figure 2.3: Left: Green Roof (Baldwin, 2022) Right: Bioswale (Dreiseitl, 2012)

Figure 2.4: Infiltration crates (Wavin, 2017)

2.2. Permeable Pavements

Permeable Pavement Systems (PPSs) is a relatively old concept within SUDS with, as mentioned before, the first use in the 1970s and 1997 in the Netherlands (Beenen and Boogaard, 2007; Thelen, 1972). Pavements make up a significant percentage of the total impervious area in urban areas specifically and thus contribute significantly to the amount of runoff that discharges into the sewer system (Mullaney and Lucke, 2014). This makes implementing PPSs a strong mitigation strategy in dealing with climate change issues since it does not require significant amounts of space and can be multi-functional. It can also be cost-effective if correctly designed and maintained (de Graaf-van Dinther et al., 2021). All types of PPSs perform similarly from an infiltration standpoint (Bouwmeester, 2023).

Although PPSs are relatively old, numerous barriers challenge their implementation on a broader scale (de Graaf-van Dinther et al., 2021, Drake et al., 2013).

Currently, available literature identifies four categories of PPSs (Mullaney and Lucke, 2014, Scholz and Grabowiecki, 2007, Drake et al., 2013). Green parking is the latest development and is not featured in literature as much as the other categories. Together with green parking, the four main categories are:

- Porous Asphalt (PA) (Figure 2.5).
- Porous Concrete (PC) (Figure 2.5).
- Porous Pavers (PPs) (Figure 2.6).
- Permeable Interlocking Concrete Pavers (PICPs) (Figure 2.6).
- Green Parking (Figure 2.7 and Figure 2.8).

Figure 2.5: Left: Porous Asphalt (Mrugacz, 2017) Right: Porous Concrete (Kumar, 2021)

PA and PC are comparable systems as they both rely on an open structure to let water through (Drake et al., 2013, Scholz and Grabowiecki, 2007). PA has been used on Dutch highways since 1987, aiming to drain water from its surface faster than normal asphalt. Noise reduction has also been named an additional benefit (Tromp, 1993). PC consists of a special type of cement binder that improves infiltration capacity (Mullaney and Lucke, 2014, Kayhanian et al., 2015). PC can also be used to produce PPs.

PPs (Figure 2.6) have an open structure that allows for the infiltration of water (UrbanGreenBlueGrids, 2022a). Underneath the pavers, coarse sand is applied to improve the capacity for infiltration and storage of rainwater. A known downside of PPs is the clogging that might occur after years of use. This can be due to sediments or leaves falling from trees in autumn and is inevitable (Kayhanian et al., 2015). This downside can be mitigated using a so-called 'ZOAB-Cleaner', which is expensive and might not fit some municipalities' maintenance budget (UrbanGreenBlueGrids, 2022a). Other factors also play a role in the long-term functionality and infiltration capacity, like the materials, local soil composition, the composition of the foundation, and the construction methods used (Kayhanian et al., 2015, Boogaard et al., 2014). As more research is conducted focusing on the long-term working of PPs and other PPSs, solutions for these issues are better understood and dealt with (Mullaney and Lucke, 2014).

Traditional pavers have fine sand in the openings in between pavers to improve stability. PICPs (Figure 2.6) have permeable material instead, allowing water to infiltrate in between the pavers. These openings are typically about 5-15% of the total area of the pavement but can vary depending on the design (Lucke and Beecham, 2013). Both PPs and PICPs allow for extra drainage pipes and geotextiles to be added to increase infiltration rates and storage capacity. Clogging of the openings is also a known issue for PICPs. However, research has shown that for both PICPs and PPs, even when clogged, the infiltration rate is still relatively high even several years after implementation (Boogaard et al., 2014).

Figure 2.6: Left: Porous Pavers (UrbanGreenBlueGrids, 2022a) Right: Permeable Interlocking Concrete Pavers (PCA, 2018)

The newest of all PPSs is green parking, which consists of open voids between pavers with vegetation growing in the open spaces (UrbanGreenBlueGrids, 2022b). It was initially used to reinforce road verges in case of a need to evade an obstacle on the road, e.g., for cars moving in opposite directions to pass each other. Since then, it has been mainly used in (as the name suggests) parking spots, but recent projects have shown it can be implemented in residential streets as well (Figure 2.9).

The size and shape of the voids and the used materials highly differ across manufacturers and depend on various factors. The first one is the location; depending on traffic intensity and the type of traffic (ambulances, heavy vehicles), voids might be designed smaller to deal with higher loads. Another factor to take into account is the type of material used, which varies from (recycled) plastic to different sizes and shapes of concrete slabs or pavers (Figure 2.7). The design is also dependent on the soil composition and its infiltration rate. In recent years this has started to play a more significant role, and different substrates are explicitly produced for green parking focusing on optimizing the infiltration rate and vegetation growth. Companies have also formed partnerships to optimize the infiltration rate and quality of grass growth. Different types of grass are also being tested, either a single type or a combination of multiple grass types, with a focus on the growing season, growth speed, and impact on biodiversity. Other vegetation types, such as sedum, are also being tested (Figure 2.8).

Little research is available on green parking (Mullaney and Lucke, 2014; Rooze et al., 2021). Most published research focuses on the (long-term) infiltration capacity of PPs and PICPs. (Brattebo and Booth, 2003) studied the long-term infiltration capacity of multiple variants of PPSs, including two variants of green parking. After six years, the infiltration rate was still up to standard, and almost all precipitation was infiltrated. The water quality of the infiltrated water was higher compared to street runoff based on heavy metal concentrations. Although this study is promising, the soil was permeable, making infiltration easier. Locations with less permeable soils might have different results. The impact of traffic intensity is also not understood well. Higher parking intensity is thought to harm grass growth, but this is not always the case. Other factors also play a role, for example, the difference in the times when the parking takes place (at night versus during the day). These factors have not been thoroughly researched in order to form a definitive conclusion.

Figure 2.7: Left: Green parking using concrete tiles (Bouwens, 2022) Right: Green parking using recycled plastic (“TTE Infiltratierooster”, 2018)

Figure 2.8: Left: Green parking using concrete pavers (Stuyver, 2021) Right: The latest development in green parking: sedum instead of grass (Bouwens, 2022)

Figure 2.9: Green parking implemented in new ways (Climatescan, 2021; SwaansInfra, n.d.)

2.3. Pilots

With the increased attention being paid to climate change and climate adaptation, interest in experimental approaches for new policy and innovative technologies has also increased (Kivimaa et al., 2015; van Popering-Verkerk and van Buuren, 2017). Pilots are one of these experimental approaches.

Pilots are often the first step in the implementation of new policy or technology and are considered vital in upscaling innovations to a city-wide level (Liu et al., 2019; Von Wirth et al., 2019). In urban water management settings, pilots are small-scale projects used to further research innovations outside of currently used methods and allow for exploration and experimentation with different products or methods (Vreugdenhil et al., 2010).

This means fewer risks are involved in a pilot project compared to a regular size standard municipal project. These risks are primarily financial since a smaller scale means fewer resources need to be used and in case of failure, the costs will be lower. As risks are generally lower, using pilots is an excellent way to get skeptical stakeholders involved in the project (Vreugdenhil and Rault, 2010; Vreugdenhil et al., 2010). These stakeholder interactions can help convince skeptic stakeholders (i.e., different departments in the case of municipalities) to change methods or products. Another benefit of stakeholder involvement is that new collaborations can form between departments that do not communicate often.

The exact definition of a pilot is flexible, and there are a lot of different variations, but they all share some key characteristics that set them apart from other types of projects (van Popering-Verkerk and van Buuren, 2017; Vreugdenhil and Rault, 2010):

- Pilot projects are of a smaller scale. This is done to minimize costs and also lower risks. The lower costs also mean that a failure is not as detrimental as it would be for a regular project.
- Pilot projects fall outside of the normal project structure. This allows for some freedom to use different products or to try different methods that would normally not be allowed or used in the regular project structure. This also means that the typical hierarchical structure might be different.
- Pilot projects have a specific aim or goal. This goal must be specified and agreed upon by the stakeholders beforehand. This goal should also be explicit and measurable so a pilot can be determined a success or failure.
- Compared to a regular project, a pilot project involves partnerships between stakeholders outside the regular project structure. It can also enhance existing partnerships.
- Flexibility is important for a pilot project since it involves new methods or innovative products, and unexpected events might occur. This means a certain risk of failure has to be accepted by everyone involved.
- Pilots have a clear beginning and end. This also involves clear next steps regarding upscaling or further pilot projects.

The objective of a pilot is or should be the development of knowledge and experiences and for those experiences to be upscaled. In the case of innovations, the aim would be for them to become standardized and implemented into regular municipal projects. In order for this to happen, the stakeholders' approach should be open and collaborative and accepting of the fact that possible risks exist (Vreugdenhil and Rault, 2010). Even failed pilots provide valuable knowledge and experiences as long as the pilot is set up in a sufficient manner so that there can be an evaluation at the end (Vreugdenhil et al., 2010).

Two types of failures can be distinguished: a failed pilot setup or a failed result. A failed result means that the product tested did not live up to expectations and did not meet the standard agreed upon before starting the pilot. The knowledge gained from the pilot leads to the product not being used again, saving costs on potential future failures. A failed pilot setup means no experience or knowledge is gained; this can occur due to multiple reasons. An overview of characteristics and possible reasons for failure are listed in Table 2.1.

One reason for a failed pilot setup to occur is when no clear goal is established. Upscaling is difficult when no clear goal is set since the results have little real-life applicability (Vreugdenhil et al., 2010). Before the pilot starts, real-world relevance and potential upscaling are essential to keep in mind; this also means that consensus needs to be reached on what a success or failure would look like. The scope can turn out to be a reason for a pilot to fail as well. A balance exists between the cost and scope since widening the scope also increases the costs. In some instances, saving costs might mean the defined scope is too narrow, consequently resulting in the lessons learned being limited (Vreugdenhil et al., 2010).

Another reason for a pilot to fail involves poor or no monitoring. This can be the total absence of monitoring, monitoring incorrect irrelevant aspects, or not reporting the monitoring results correctly. As mentioned in the list of pilot characteristics, having an explicit and measurable goal is essential. For the goal to be measurable, proper monitoring needs to take place so results can be analyzed and evaluated for potential upscaling (R. E. De Graaf, 2009; de Graaf-van Dinther et al., 2021; Mattingly, 2008).

Stakeholder involvement can be either beneficial or harmful to the success of a pilot. Increasing the number of stakeholders involved means that the results are more likely to be relevant for regular projects as additional points of view and experiences are considered. However, it also allows for the scope to be wider, which will result in an increase in costs. The downside is that as a higher number of stakeholders get involved with the pilot, difficulties relating to managing the pilot arise since it is harder to agree on a goal or monitoring method when more people have decision-making power (Van Buuren and Loorbach, 2009; Vreugdenhil et al., 2010). To reach an agreement on goals, methods, results and what a success would entail, compromises may have to be made, making the pilot's results less applicable in regular projects or less useful for upscaling. A solution to manage a big group of stakeholders is to assign a 'pilot manager' to streamline the process. This, however, will generate further costs.

Table 2.1: Pilot characteristics and potential pilot failures (van Popering-Verkerk and van Buuren, 2017; Vreugdenhil and Rault, 2010)

Table 2.2: Pilot characteristics

Pilot Characteristics
Small scale
Falls outside of normal project structure
Specific goal or aim
Variety of stakeholders
Allows for flexibility
Clear beginning and end

Table 2.3: Potential pilot failures

Potential Pilot Failures
No clear goal
No consensus on success
Poor or no monitoring
Stakeholder involvement
too narrow or too broad
Lack of follow-up plan

Lastly, lacking a follow-up plan can lead to the failure of a pilot. As previously mentioned, the end goal of a pilot should be the development of knowledge and experiences and for those to be upscaled or even standardized. Before the pilot starts, the follow-up steps must also be established (Suleiman, 2021).

The follow-up of a pilot can take multiple routes and is also referred to as 'diffusion,' shown in Figure 2.10. This process can take three routes. The first one is the upscaling of a pilot. This means the pilot will be replicated within the same organization (a municipality in the case of green parking). Still, different aspects might be upscaled, such as the location, the amount of stakeholders involved, or the number of factors monitored during the pilot. Another route is for the pilot to be replicated in other areas. In the case of urban water management, this would mean that municipality B would perform a pilot project on the same scale and setup performed by municipality A. The last route is the path that leads straight from a pilot to the tested product or method being implemented into the regular project structure.

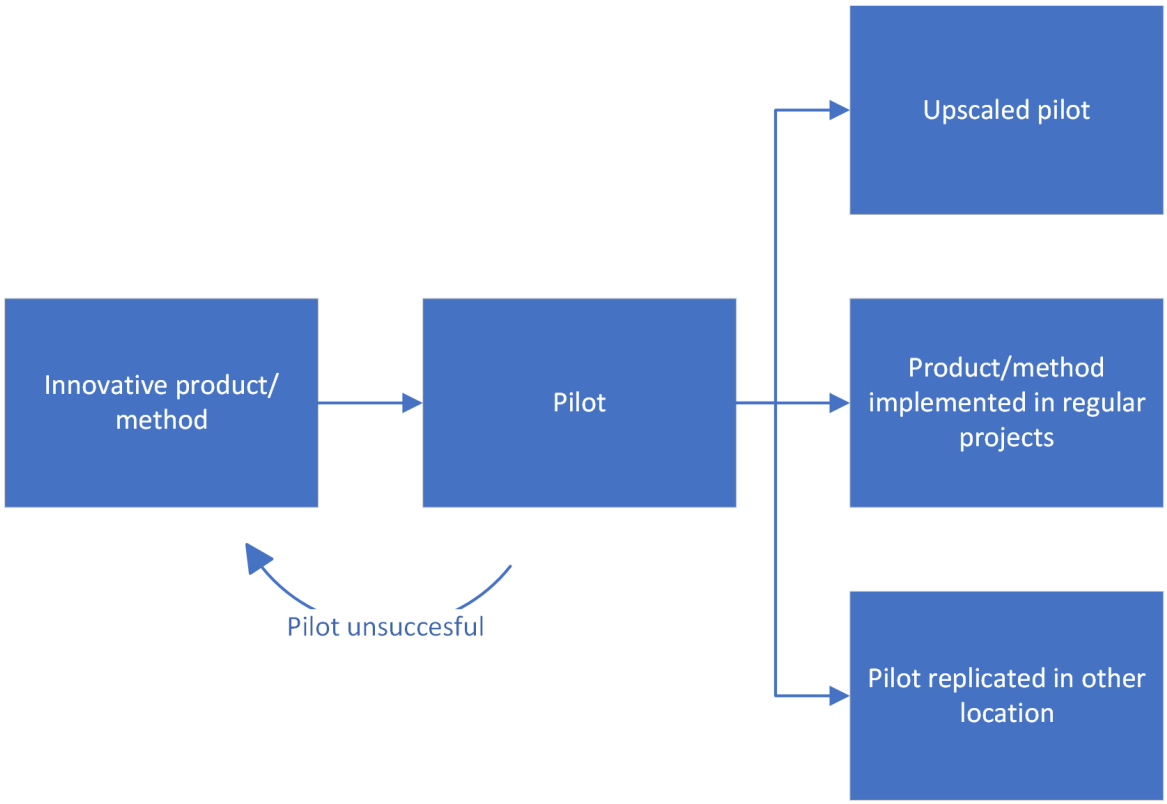

Figure 2.10: Follow-up steps for pilots adapted from Vreugdenhil and Rault, 2010 and Vreugdenhil et al., 2009

The route shown in Figure 2.10, going from pilot to product/method implementation, is often much more complicated in the case of urban water management involving municipalities. Based on the theory of change (Van Es et al., 2015), (de Graaf-van Dinther et al., 2021) formed a framework outlining the steps from a pilot project to transformative infrastructure (Figure 2.11).

The figure displays the complexity and the various steps involved in widely implementing an innovative product. A great number of these factors directly or indirectly relate to information sharing between stakeholders. However, multiple steps also depend on a proper pilot setup, which would lead the innovation to the next phase of implementation.

The figure shows two axes, pilot projects start in the top left quadrant, and as the pilot scales up and the innovation becomes more mainstream, it moves to the bottom right quadrant. (de Graaf-van Dinther et al., 2021) describes two shifts needed for pilots to move towards mainstream implementation.

The first shift, on the horizontal axis, involves stakeholders. This starts with stakeholder awareness (left) and moves towards performing a societal cost-benefit analysis (right). On the vertical axis, pilots

go from small-scale tests (top) to testing full-scale testing; this includes maintenance.

Both axes are essential in the widespread implementation of green parking and other permeable pavements.

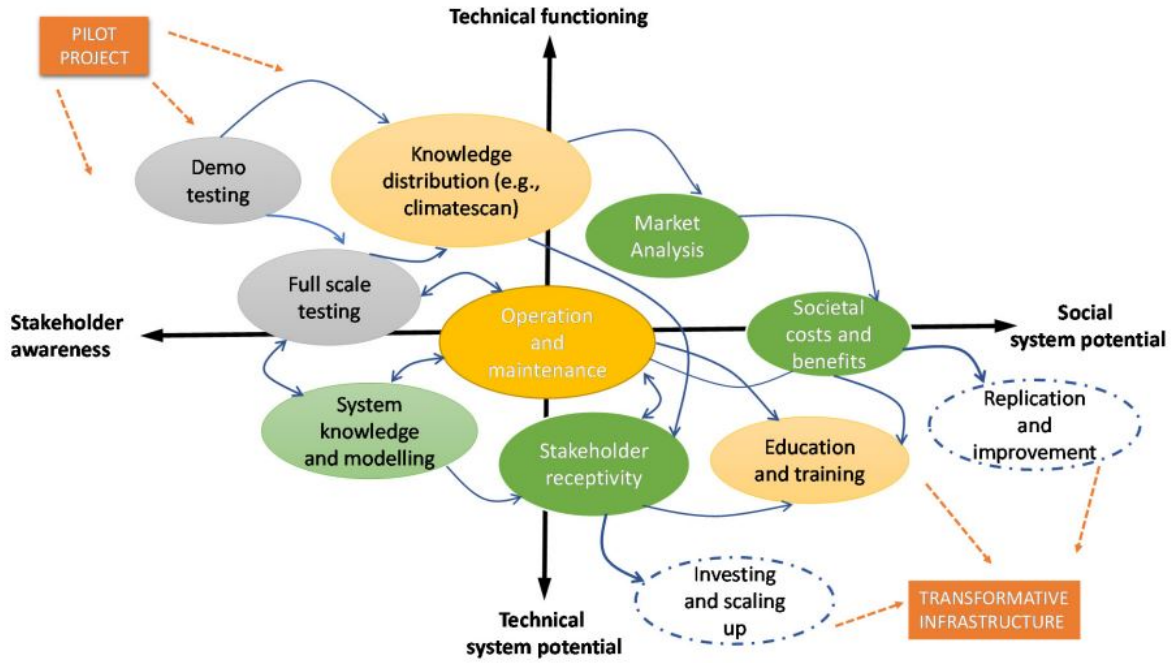

Figure 2.11: Factors involved in moving from pilot projects to transformative infrastructure (de Graaf-van Dinther et al., 2021), based on theory of change (Van Es et al., 2015)

2.4. Transition Management

2.4.1. The Multi-Level Perspective

To place the implementation of green parking and other innovations into the wider context of transition management and the way systems change and adapt to new innovations, multiple frameworks that have been described in the literature can be considered. The Multi-Level Perspective (MLP) is used in this section to describe the interaction between levels of stakeholders, which will assist in analyzing interview results.

The MLP is a framework used to describe a socio-technical transition by analyzing the interactions and relations between three distinct levels: the niche level, the regime level, and the landscape level (Figure 2.12) (Geels, 2002). An important element of the MLP is the fact that there is no direct causation. Instead, processes on separate levels influence each other in different ways, and the alignment of these levels leads to innovations breaking through (Geels, 2002; Geels, 2011). This means actors of all levels need to work together for an innovation to get out of the niche level.

The niche level is where innovation takes place and new ideas are formed. These innovations are developed in small networks of dedicated actors, for example, entrepreneurs and start-ups (Geels and Schot, 2007). On this level, no innovation has reached a dominant position and consequently, there is an abundance of variety (Geels, 2002). Learning processes from small-scale implementations are an essential factor on this level, focusing mainly on their technical performance, costs, and how they fit in with current practices (Liu et al., 2019). Studying these factors on a small scale familiarizes actors and stakeholders with innovations. This small-scale implementation can then spread out in multiple ways, as described in Section 2.3 and Figure 2.10. An example related to green parking would be the Green Village, a field lab for sustainable innovations in Delft where innovations are showcased and developed by start-ups.

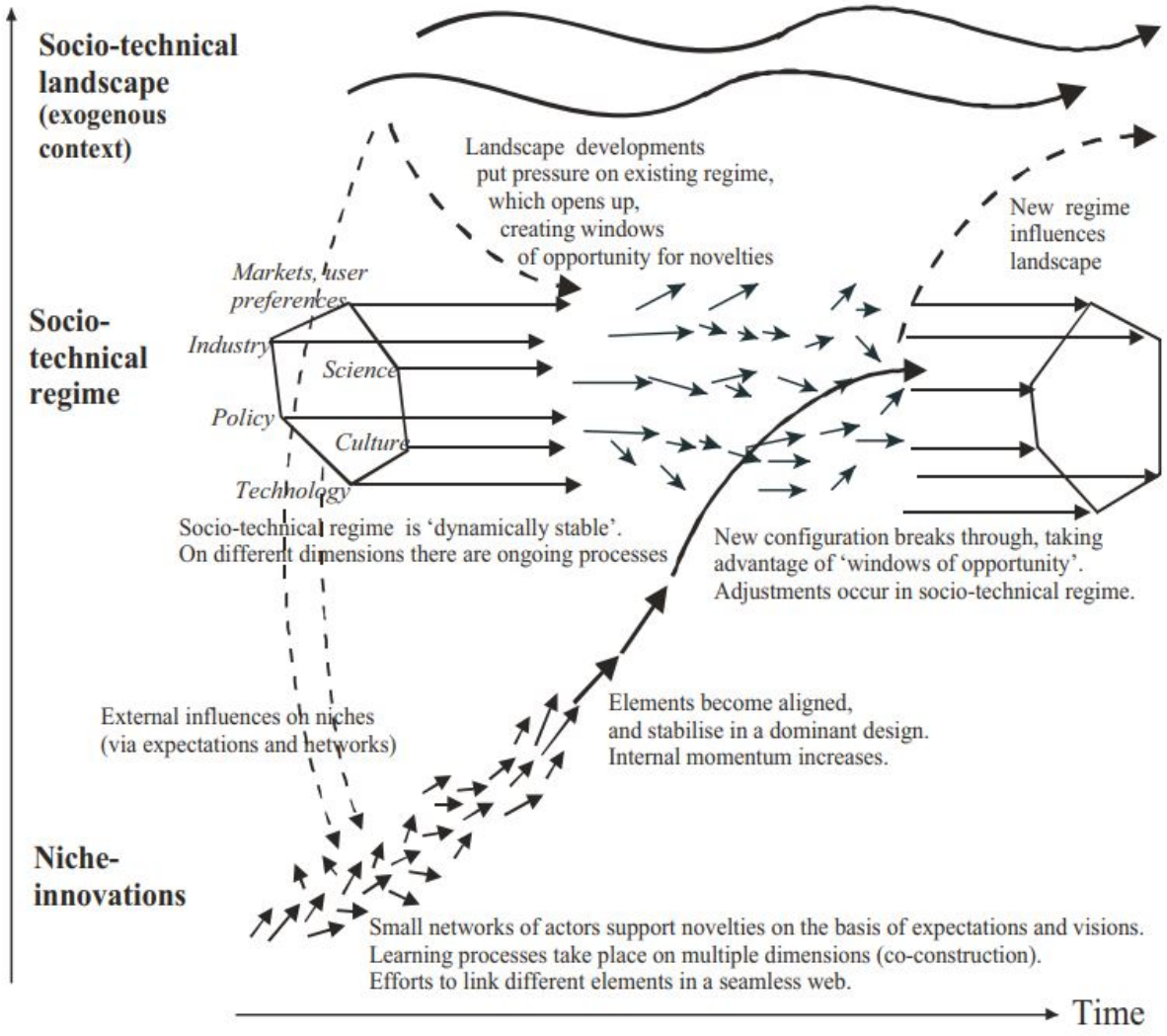

Figure 2.12: The multi-level perspective (Geels, 2011)

The second level is the regime level. This level comprises the current situation. Current methods, products, and technologies all fall within this level (Twomey and Gaziulusoy, 2014). Relating this level to green parking, this would include the current pavements and storm drains, current maintenance methods and procedures, and project structures.

Inertia causes trouble for new innovations to break through from the niche level to the regime level, causing friction between the two levels. Innovations that might seem ready for wider implementation by niche-level actors face resistance from regime-level actors due to possible long-term uncertainties about the effects. The regime-level actors might not see a need for change in the current situation (Geels and Schot, 2007; Kemp et al., 2007).

The highest level is the landscape level. This level consists of continuing developments, such as cultures, demographics, and long-term political changes (Geels, 2002). The landscape level can be influenced by external factors, including public opinion, policy, major breakthroughs in technology, or changes in society or the environment (Geels, 2002; Kemp et al., 2007).

2.4.2. Contested and Negotiated Knowledge

As pilot projects get scaled up, more stakeholders get involved; therefore, for results to be useful, a consensus has to be reached over what is going to be monitored, how it is going to be monitored, how the results are going to be interpreted, and what defines a successful pilot.

Reaching consensus becomes more complex as more actors get involved, especially in municipal projects where different departments play a role in the innovation implementation process. Each actor from a different department brings in their expertise, experiences, and biases. This can result in a conflict when trying to reach a consensus at the start of a pilot project.

A related concept is contested knowledge. This is information or knowledge in a project with competing perspectives from different actors leading to conflict. The conflict can revolve around knowledge and/or goals. (De Bruijn and Leijten, 2007) describes four types of problems related to contested knowledge (Table 2.4).

Table 2.4: Four types of problems related to contested knowledge, adapted from De Bruijn and Leijten, 2007

	Certainty about knowledge	Little certainty about knowledge
Consensus on goals	Tamed problems	(un)tameable scientific problems
No consensus on goals	(un)tameable political problems	untamed political problems

In the case of green parking and pilot projects to widen implementation, a tameable political problem is the best fit. Considering the table and green parking, specifically pilot projects to widen implementation, there is no consensus on goals, but there is certainty about knowledge. Therefore, this can be considered a tameable political problem which means that there is high certainty about the available knowledge but no consensus on goals. Multiple aspects of green parking can be measured objectively. These include infiltration, grass height, and ambient temperature. The issue lies in the consensus on goals and different values of the stakeholders involved. Many actors have different opinions and values, so they observe the objectively measurable aspects differently based on their expertise and experiences. There is also no consensus on methods used to measure the effectiveness of green parking.

The term negotiated knowledge is introduced to deal with contested knowledge and reach a consensus that will ultimately lead to wider implementation of innovations. Negotiated knowledge follows from a process of negotiations and discussions between all actors involved (De Bruijn and Heuvelhof, 2002; Van de Ven et al., 2011). This process produces a lot of actor-specific information, which has to be agreed upon. They have to decide what will be measured to determine whether or not the pilot is a success and how it will be measured (methods used). A possible role in this process might be reserved for 3rd party companies that provide product certifications on aspects like environmental impact. An example is the Milieukostenindicator (Environmental Cost Indicator) (MKI), which expresses environmental impact in monetary value. They can act as an intermediate and neutral party in the validation of information. Another option is to assign a process manager to reach negotiated knowledge. However, both 3rd party certification and a process manager are quite costly, so the need for these options must also be agreed upon.

2.4.3. Agent of Change

During the interviews and in the literature, motivated individuals were often mentioned. This section describes these motivated individuals, often called agents of change.

The concept of the agent of change refers to a person (or sometimes a small group) that initiates and manages change in an organization based on intrinsic personal motivation (Lunenburg, 2010). Agents of change are characterized by two aspects. One of these aspects is being in a position to be able to influence change, although this does not necessarily mean that the agent of change needs to be a manager. A good working relationship with managers is essential if the agent of change is not in a managerial role. The second is that the agent of change uses their influence to change the current system (Koop et al., 2017). Agents of change are often mentioned as being an essential factor in implementing new technologies or in transforming an organization (de Graaf-van Dinther et al., 2021; Hughes et al., 2020; Suleiman, 2021; Wittmayer et al., 2017).

Three types of agents of change are defined in the available literature (Ford and King, 2015; S. Brouwer and Huitema, 2018; Koop et al., 2017):

- Entrepreneurial agent: have the skills to access resources from different stakeholders and use management skills to look for opportunities for change.
- Collaborative agent: use their network and social skills to build connections between different internal and external stakeholders.
- Visionary agent: influence the current system (or regime) by linking short-term goals with long-term adaptations and plans.

While agents of change are not capable of changing the entire system by themselves, or in terms of MLP, moving innovation from the niche level to the regime level, they can help achieve a culture of change and inspire other stakeholders (Hughes et al., 2020; Lunenburg, 2010). This can also be linked to pilots as agents of change are essential in diffusing the results from a pilot project.

2.5. Climate Adaptation Strategies

As mentioned in the introduction, the DPSA was established as part of the Delta Programme. The DPSA contains seven ambitions to make the Netherlands more water-resilient and climate-proof (Figure 2.13). The DPSA also includes plans for each municipality to conduct so-called 'stress tests'; these have the aim of mapping out vulnerabilities (Delta Programme Commissioner, 2017). These eventually evolved into a climate adaptation strategy, focusing on multiple themes: heat, floods, and droughts.

Figure 2.13: The seven ambitions of the Delta Plan on Spatial Adaptation (Delta Programme Commissioner, 2017)

Based on the ambitions from the DPSA, the province of South Holland, multiple water boards, municipalities in South Holland, and private companies signed the climate-adaptive building covenant (Dutch: Convenant klimaatadatief bouwen). Its goal is to improve collaboration between the private and public sectors and detail specific measurable guidelines based on the seven ambitions from the DPSA. For green parking, the infiltration guideline is most relevant. The covenant states that 20% to 100% of yearly precipitation should be infiltrated within the project area (Provincie Zuid-Holland, 2018).

These specific guidelines are adopted in municipal climate adaptation strategies. These strategies form the basis of the plans to deal with climate change, so they are also relevant to implementing green parking and other innovations.

Still, some municipalities struggle to translate policies into concrete projects dealing with climate adaptions, and strategies vary greatly in how concrete the goals are (M. Brouwer and Wessels, 2021). This is partly due to a lack of knowledge of climate-related issues. Some municipalities also lack information on the effectiveness and long-term costs of measures they can take (van Bijsterveldt et al., 2021). Other issues mentioned include the fact that specific measures (e.g. green parking) deal with a lack of clear responsible departments. The reason is that they do not fall within one department's responsibilities and the fact that climate adaptation is not always seen as a priority by everyone involved (van Bijsterveldt et al., 2021; M. Brouwer and Wessels, 2021).

2.6. Literature Review Conclusions

The main conclusions drawn from the literature review are the following:

- SUDS have gained in popularity in recent decades. The number of different names and intended goals has also increased.
- SUDS can be categorized in multiple ways based on goal, type of technology used, or its place in the water cycle.
- Permeable pavements consist of four main categories. Green parking is the newest one.
- Little research exists on green parking.
- Pilot projects have no exact definition. Still, they share several key characteristics.
- Pilot projects can be an essential step in implementing a new product or method if certain potential failures are avoided.
- MLP describes three levels of transitions, each with its actors and goals. Change happens when different levels align and work together.
- Contested and negotiated knowledge can be linked to the upscaling of pilots, especially regarding reaching a consensus on goals and methods.
- Agents of change can influence systems and play an important role in innovation implementation.
- Municipalities have formulated climate adaptation strategies but still struggle with translating climate adaptation goals into concrete projects. This also affects the implementation of innovations.

3

Research Process and Methods

This chapter discusses the research process and the methods used. It is divided according to the research structure.

First, Section 3.1 describes the preparation completed before starting the research and explains how the topic and case study were selected. Subsequently, Sections 3.2, 3.3, 3.4, and 3.5 each describe the methods used and how data was collected, processed, and analyzed per research phase.

3.1. Preparation

The first step in the process was defining the lens through which the topic of innovation implementation was going to be viewed. After multiple meetings with supervisors and VPDelta+ and a preliminary literature review, information was picked as the lens. The research structure, questions, and scope were also defined during this period. The case study was first considered through personal communication and further discussed with VPDelta+.

The Double Diamond (Section 1.3) structure was ultimately decided upon because the factors involved in implementing green parking were poorly understood. Using this structure allowed for quick adaptation to new insights from interviews and literature. It also allowed for a possible change of focus halfway through the process, where a reflection on the results could occur, identifying what was still missing and what needed to be researched further. Finally, the structure was helpful as the key issues were not understood at the beginning of the process. Defining research questions and methods around a poorly apprehended problem would not be beneficial to the final result.

The last step in the preparation phase was determining what methods would be used during each subsequent phase. An overview of the methods and research questions answered per phase can be found in Table 3.1.

Table 3.1: Methods used and research questions answered per research phase

Phase	Research Question	Document Analysis	Literature	Interviews	Results Previous Activities
1	1.1 1.2	x	x		
2	1.3 1.4			x	x
3	2.1 2.2 2.3 2.4	x	x	x	x
4	2.5				x

3.2. Pre-Interview Research

The first activity is the pre-interview phase. The methods associated with this phase are literature and document analysis. The initial questions for this phase were formulated to find out more about different aspects of the case study product, for example:

- What are the different product types and manufacturers?
- What is the history/background of the product?
- Where is it already being used and in what capacity?

3.2.1. Literature Review

These initial questions functioned as a starting point for the literature review. The literature review aimed to get an overview of the product's use and possibly find patterns of where and in what capacity it is being used. It also gave an impression of the companies producing the product that can then be contacted for a possible interview opportunity.

As more literature was found, new questions arose that were either further researched or served as interview questions later. The search for literature was initially conducted on a broad scale and remained general. After trial and error, key terms led to more applicable literature on relevant topics. The snowball method was also used; for relevant articles, different articles by the same author or authors were reviewed (TUlib, 2016b). In addition, the bibliography of important papers would be examined for further potentially relevant literature.

To ensure that the literature found was suitable and reliable, (TUlib, 2016a) was used as a guideline. It provides information on how to look for literature and to evaluate them as usefull. For example, by looking at the publishing date, the publishing history of the author and the type of journal it was featured in. During the interview phase, different literature papers and topics were noted by interviewees. This started a second round of literature review focused on issues that were not previously studied because they were either not known or seemed irrelevant initially.

3.2.2. Document Analysis

The document analysis started with two different approaches. The first one was from the viewpoint of companies involved in green parking. Companies were found through online searches and the Green Village. The initial questions that started the search were:

- What types of green parking are available?
- What are the main channels of information for companies?
- How does this information get to municipalities?

The questions were answered by initially looking at company websites, which gave a basic overview of the different types of green parking and how information is presented. It also provided an impression of the companies producing the product that could then be contacted for a possible interview opportunity. During later phases of the thesis, more sources became available via interviewees or through the network of the supervisors.

The second approach focused on municipalities and policy. First, policy documents were analyzed to learn more about the context of innovation implementation. This started with the Delta Programme and the Water Act to determine the legal basis and the urgency for climate adaptation and innovations. After interviewees from municipalities were identified, this search was narrowed to focus on specific documents published by those municipalities. At first, these included the climate adaptation strategies and Gemeentelijk Rioleringsplan (Municipal Sewage Plan) (GRP) from various municipalities. This search was mainly carried out to formulate interview questions.

As interviews were conducted, more documents were found, such as municipal spatial design guidelines. This is a handbook of guidelines for municipal renovations and new urban developments. Ques-

tions about these documents were formulated once it became known that they played a role in implementing green parking, making the document analysis an iterative process.

Different websites, databases, and other sources were also used. These were found through interviewees, supervisors, literature, or websites via the snowball effect. These sources were studied to formulate interview questions and to identify interviewees. Another reason was to identify barriers to implementation or to rule out others. The sources used include the CROW and NEN-Connect reports, found through the TU Delft library, and websites like 'Bouw Adaptief' and Klimaatadaptief bouwen met de natuur (Climate-adaptive building with nature) (KAN).

3.3. Interviews

The primary way data was collected for this thesis was through interviews. This part of the thesis consisted of preparing the interviews by picking the interview style, formulating questions, and processing the interview data. The methods used in this part of the thesis are interviews and the results from previous activities, as identified in Table 3.1.

The goal is to answer questions related to the current manner in which municipalities handle the implementation of innovations, mainly the following points:

- What is currently missing from the available information?
- What are the differences between municipalities?
- What are the weaknesses and strengths of the implementation process?
- What are the key issues?

Conducting interviews meant that the thesis would be qualitative rather than quantitative. Qualitative research is often conducted using face-to-face methods; interviews is one of the most frequently used methods and are used to observe characteristics of organizations or individual behavior (Lapan et al., 2011). Since the goal is to understand the implementation of innovations, in this case, green parking, understanding organizations (municipalities and companies) and the individuals involved is essential.

Interview styles vary from structured to unstructured. One end of the spectrum is the structured interview, which has a fixed list of questions the interviewee must answer. It has the advantage of easily comparing interviewees' answers since they were all asked the same questions. A disadvantage is the fact that it does not allow for flexibility. Since the key issues were not well understood beforehand or unknown, using a structured interview would mean missing out on valuable data. The other end of the spectrum is the unstructured interview. Although it is hard for an interview to be truly unstructured, unstructured interviews do not have a fixed list of questions or themes outlined beforehand (DiCicco-Bloom and Crabtree, 2006). This option was not chosen since the literature review and document analysis inspired potential interview themes and questions, then used as interview starting points. Ultimately, a semi-structured approach was found to be the best structure for data collection. The main advantage of a semi-structured approach is that it allows for flexibility and versatility based on the interviewee and the data needed (Kallio et al., 2016).

Interview guides were formulated according to the principles of a semi-structured interview. These consisted of main themes and several optional follow-up questions (DiCicco-Bloom and Crabtree, 2006; Kallio et al., 2016). The goal of the semi-structured interviews was to make the interviewees feel as comfortable as possible to share any experiences, thoughts, or perspectives they might have on the topic. This prevented any blind spots in the questions and led to open conversation.

The themes were based on the literature review, the document analysis, and the research questions and were different based on the specific role of each interviewee. The different themes can be found in Table 3.2. The interviews started with some general questions for municipalities and companies. These were related to the person, their job, and their involvement in the implementation process.

Table 3.2: Interview Themes

Municipality	Company
General	General
Internal Processes	Product Development
Product Information	Contact with Municipalities
External Processes	

For municipalities, the themes revolved around three flows of information: internally between different departments; how they received and searched for information on green parking products; and externally between them and other municipalities and other levels of government like the national government and the waterboards (Figure 3.1). For companies, the first theme revolved around their product and how it was developed, tested, and marketed. The second theme concerned how their contact with municipalities was handled. The interview guides for both municipalities and companies can be found in appendix A and B, respectively.

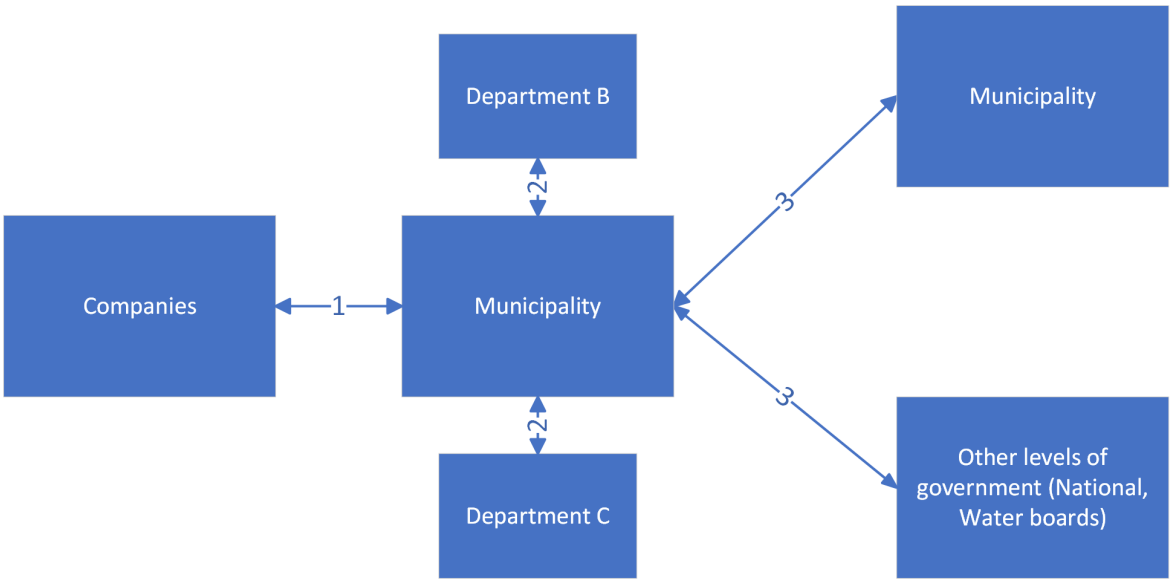

Figure 3.1: Three flows of information: (1) between companies and municipalities, (2) between departments of the same municipality, (3) between municipalities and other levels of government

The follow-up questions were formulated using an iterative process. Based on the pre-interview research, several questions were initially used. After the first couple of interviews, these were rephrased based on how well they fit the interviews and how clear they were to the interviewees. This turned into an iterative process where, as time went on, questions were replaced when needed. This could be because certain topics did not turn out to be as relevant as anticipated, or new topics were brought up by interviewees that warranted further questions to be defined. Another step was to cater specific questions to certain interviewees. These questions were only used when an interviewee had particular knowledge or information deemed especially relevant to the thesis. Every interview ended with the same question; the interviewee was asked if there was anything they felt was relevant to the thesis and did not come up naturally. This ended up being helpful in finding new possible issues to research and providing new sources and potential interviewees. Figure 3.2 visualizes the iterative question process.

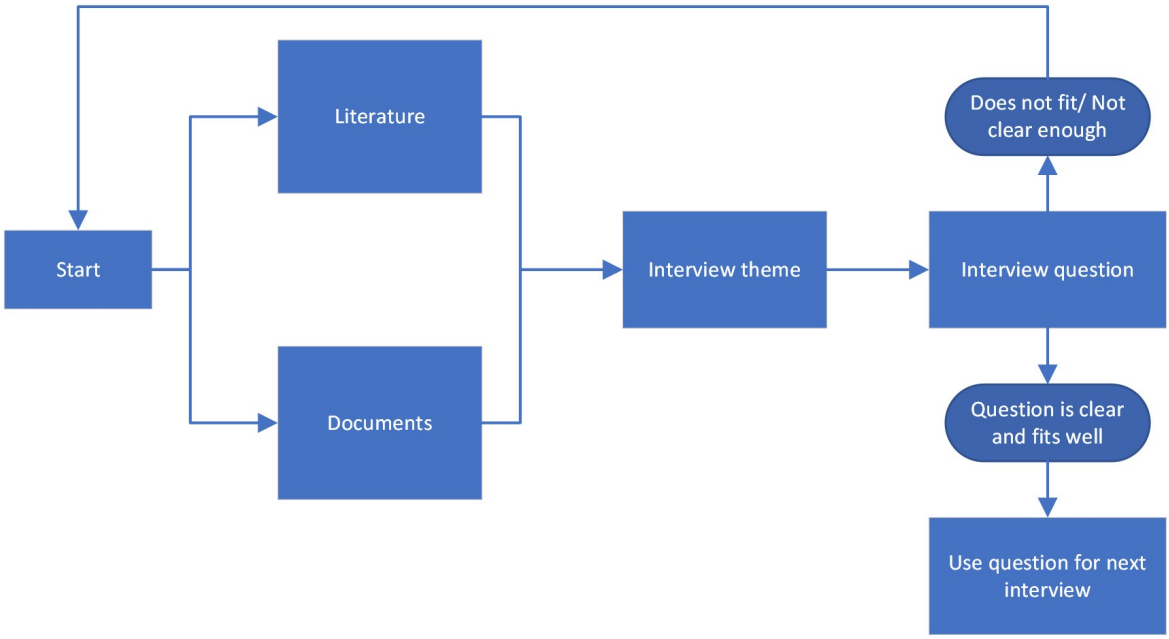

Figure 3.2: Iterative question process

Interviewees were initially selected with a vast scope. Various municipalities and companies were approached through personal contact and the network of supervisors and VPDelta+. Not everyone contacted responded or showed interest, but everyone who responded was interviewed regardless of how involved they were in the innovation implementation process. The choice for a broad scope was based on the research structure and made to obtain as much information as possible in the early stages of the thesis to specify key issues. Table 3.3 gives an overview of all interviewees for the problem phase. Table 3.4 shows the municipalities that were interviewed, the number of interviewees from each municipality, and some basic characteristics.

Table 3.3: Interviewees for the problem phase

Interviewee #	Position	Type of Organization
1	Sewer system consultant	Municipality
2	Climate adaptation consultant	Municipality
3	Contract manager	Municipality
4	Civil engineer	Municipality
5	Pavement maintenance team	Municipality
6	Pavement maintenance team	Municipality
7	Project manager	Municipality
8	Project manager	Municipality
9	Project manager	Municipality
10	Green parking consultant	Company
11	Account manager	Company
12	Account manager	Company
13	Department head	Company

Interviews were conducted using Microsoft Teams. This method was chosen because of the transcription and video function. Due to the automated transcription, taking notes was not essential, and complete focus could remain on the interview itself. Before the interview, interviewees were asked to sign a consent form, which explained the research aim and explained how data from the interview was used and analyzed. The consent form also outlined the ways the privacy of the interviewees would be guaranteed. After the interview, transcripts were analyzed using the video recording to adjust the transcription in case of computer error or misunderstanding.

Table 3.4: Municipalities interviewed for the problem phase (CBS, 2023)

Municipality	Inhabitants	Area (km^2)
Delft	106.086	22,65
Westland	114.887	81,27
Midden-Delfland	19.472	47,19
Zoeterwoude	9.443	21,19

The next step was determining when to cease the interview process. Two factors played a role in this decision. The first is the fixed end date for the problem phase of the thesis. The second one is the concept of saturation, the point at which no new information is observed in the data (Guest et al., 2006). Another study found that most interview codes were defined within the first ten interviews (Hennink et al., 2017). Although each interview offered new insights and unique perspectives, towards the end of the process, the need for analysis and readjustment of the scope was needed, and the saturation point was close. The last step of this part of the thesis was to finalize the interview codes and group them according to the themes defined in Table 3.2 and new ones discovered during the process. The program used was Atlas-TI, found through the TU Delft online software catalog. Key issues were defined, and one was picked to focus on during the solution phase.

3.4. In-Depth Research

The second half of the thesis, the solution phase, started after the analysis performed at the end of the problem phase. Again, key issues were defined, and one was selected as a main focal point: pilots.

The methods used for this part of the thesis include all four methods defined in Table 3.1. First, the results from previous activities were needed to determine a focal point. A literature review and document analysis were required to become acquainted with the topic, formulate themes and general questions, and identify interviewees. Lastly, the interviews were needed to make an analysis.

3.4.1. Document Analysis and Literature Review

The first step was to perform a second literature review and document analysis. Research papers, government documents, and reports from previous pilots were studied to understand the topic more thoroughly. Interview themes were also based on this research, and several interviewees were identified through documents found online.

For the literature review, literature previously used for phases 1 and 2 were re-examined to study the key issues further and to find positive experiences regarding the implementation of green parking.

The document analysis focused on spatial design handbooks, climate adaptation strategies, and other documents that were found relevant to this part of the thesis, pilot reports, for example. The documents were found either through an online search or were recommended by interviewees. In some cases, a document found online was the reason to approach a potential interviewee.

3.4.2. Interviews

As a result of the narrowing of the scope, the interview style shifted slightly towards a more structured style while maintaining the semi-structured elements that were determined to still be relevant for this part of the thesis. Thereafter, the initial research interview themes were formulated, which were primarily related to pilots the interviewee was involved in, is currently involved in, or is planning on being involved in in the future. The interview guide can be found in appendix C

The final interview guides consisted of the general questions used during the problem phase, new questions based on pilots, and personalized questions for each interviewee. These questions were based on the interviewee's role, company, and the specific information needed. These questions were based on secondary research conducted before each interview. Figure 3.3 visualizes the steps that were taken to formulate the interview questions.

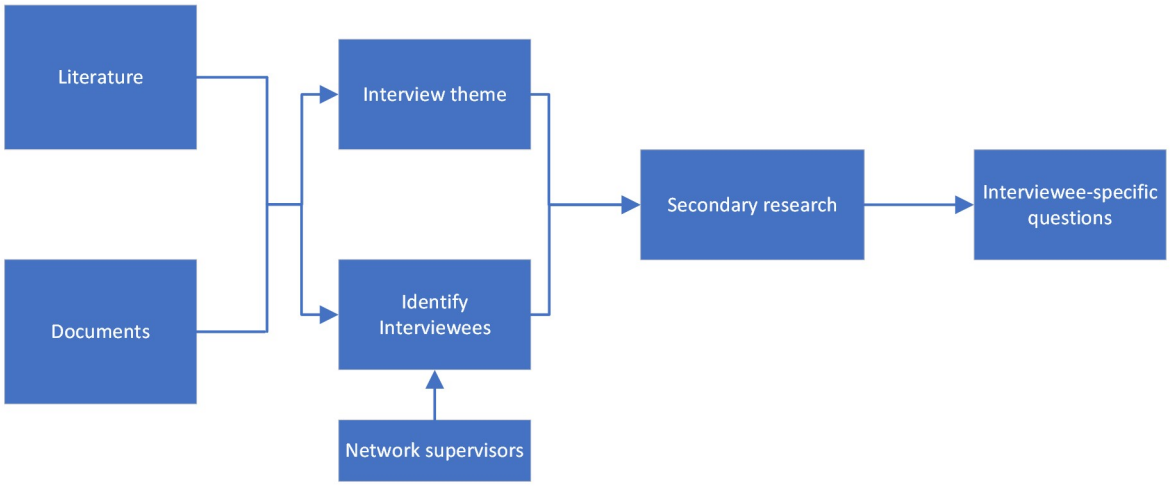

Figure 3.3: Interviewee and question identifying process for the solution phase

Interviewees were found and selected in multiple ways. The main goal was to focus on solutions as opposed to problems. As a result of time restrictions, the scope through which interviewees were found was significantly narrower and concentrated chiefly on positive pilot experiences. Through the literature review, multiple interviewees with positive pilot experiences were found and contacted for interviews. The network of the supervisors provided the other interviewees. Table 3.5 shows all the interviewees for the solution phase of the thesis and 3.6 shows the municipalities that were interviewed, the number of interviewees from each municipality, and some basic characteristics.

Interviews were conducted via Microsoft Teams since experiences from the interviews during the problem phase were positive. The analysis was carried out using the transcripts and interview recordings. Subsequently, they were coded using Atlas-TI. Some codes and themes remained from the problem phase, while others were catered towards the solution phase and thus focused on positive experiences in general and pilots in particular. Saturation was nearly reached toward the end of the interviewing process when fewer new insights were gained from each interview, and possible solutions and recommendations began to take shape.

Table 3.5: Interviewees for the solution phase

Interviewee #	Position	Type of Organization
14	Civil engineer	Municipality
15	Climate adaptation consultant	Municipality
16	Pavement maintenance team	Municipality
17	Department head	Company
18	Climate adaptation consultant	Company
19	Pilot initiator	Company
20	Consultant urban water	Company
21	General Manager	Company

Table 3.6: Municipalities interviewed for the solution phase (CBS, 2023)

Municipality	Inhabitants	Area (km^2)
Heemskerk	39.431	27,34
Deventer	102.781	130,68

3.5. Recommendations

The last part of the thesis revolves around synthesizing all the results and information into concrete recommendations helpful to municipalities, companies, and other stakeholders. Throughout the second round of interviews, options for recommendations started forming. These were also discussed during interviews to see how interviewees involved in the implementation process would respond to them. Several times, an interviewee brought up a general idea or gave their own opinion on how the implementation of green parking can be improved. These were then used as a basis for later recommendations.

4

Results and Analysis: Interviews Problem Phase

This chapter discusses the results from the interviews conducted for the problem phase of the thesis. The chapter's objective is to comprehensively give an overview of all the interview findings and to analyze them.

The interviewees for this chapter can be found in Table 3.3. Each interviewee is assigned a number to identify the source of quotes and statements used in the subsections. The chapter is structured according to the main themes introduced in Section 3.3 and displayed in Table 3.2. The subsections or key findings per theme are in chronological order based on the interviews, and the order of appearance does not signify importance.

Sections 4.1, 4.2, and 4.3 discuss the findings from the interviews with interviewees working at various municipalities. Sections 4.4 and 4.5 consider findings from interviews with company interviewees. After that, Section 4.6 will provide other findings that did not fit the different categories and an overview of the results in Figure 4.1. Lastly, Section 4.7 gives an analysis where the results will be analyzed and visualized.

4.1. Municipalities - Internal Processes

4.1.1. Goals of Green Parking

The interviews quickly pointed out that the goal of green parking is not always clear. Since it has different aspects like water infiltration, providing green areas, and being a part of traffic (as parking spots or possibly roads), each department within the municipality had different ideas of what green parking should be used for.

Every department involved, sewage for infiltration, greenery for the grass, and roads ('verharding' in Dutch) perceived green parking from their experiences, viewpoints, and expertise.

Interviewees 3 and 8 pointed out that the local circumstances determine the goal for green parking. The reason for implementing green parking was decided on a project basis. Interviewee 8 stated that it was mainly focused on infiltration because of water requirements on water storage from the water board and the municipality itself. Interviewee 3 mentioned the effects on tree growth as a possible reason. Interviewee 2 also stated that infiltration was the main reason for implementing green parking and possible heat effects were a bonus.

Creating green areas was a goal for Interviewee 7 since municipal requirements demanded a certain amount of green area per household. Infiltration did not have such requirements but was still considered important. The amount of infiltration was also a point of discussion. Some interviewees stated that the green parking spots should infiltrate all precipitation, while others accepted that some water would still be draining into the sewer system (Interviewee 1).

4.1.2. Past Experiences

"*Every colleague has had a bad experience somewhere [with green parking], sometimes from over ten years ago.*"[1]— Interviewee 2

"*If I have four projects that look nice and green and one that looks black, everyone will point at the black one.*"[2]— Interviewee 9

Previous implementations of PPSs and SUDS in general have influenced the way green parking and other PPSs are perceived by municipalities. However, even projects that happened more than 15 years ago still linger within an organization and still cause hesitancy. For example, without being asked, out of the nine interviewees, eight mentioned previous bad experiences that a colleague reffered to as a reason for not implementing green parking.

Interviewees 5, 6, and 7 all mentioned a specific project with PPs. The maintenance of the project required a particular method for which there was no budget in the maintenance department. Unfortunately, they were not informed of this during the project's design phase since they were not involved with the earlier stages and only found out after the project was finished. Since the required methods were not used due to lack of funding, the system clogged and had to be replaced after only a few years, leading to high costs for the maintenance department. Furthermore, the exact order of events and some details were unclear since it happened a couple of years ago. However, this event has led to great hesitancy on the part of the maintenance department, stressing that they want to implement tried-and-tested technologies only.

Interviewees 2 and 4 stressed that new and young people joining the municipality helped shift the mentality and attitude towards green parking and climate adaptive measures, partly because past experiences have not influenced them, bringing in fresh ideas and new questions. Having no experience was a benefit in this case.

Interviewee 9 used his experience with earlier versions of green parking to develop his knowledge and improve future projects. He stated that a good image is easily damaged due to one bad experience with green parking or other PPSs, and trust is hard to regain.

4.1.3. Expectations

People's expectations of green parking were a factor that was brought up often during interviews regarding the implementation of green parking. Of course, expectations are partly influenced by previous experiences and what people view as the goal, but other factors also play a role.

Interviewees concerned with infiltration did not have any expectations of grass growing on the parking spots, while others had high expectations of grass growth. The name green parking also created expectations of grass growth for certain people. Interviewee 4 stated that he would rather see the name changed to something more 'realistic' to manage his colleagues' expectations.

How companies promote their products online or at demo sites also influences expectations. For example, several interviewees would like more pictures and examples of less-than-perfect circumstances to show their colleagues and give them a more realistic view of green parking. They also mention local circumstances and that demo projects like the Green Village are unrealistic for their specific locations within their municipality.

[1]Original Dutch text: "Iedere collega heeft wel een slechte ervaring ergens, dat kan soms wel 10 jaar geleden zijn, hè."
[2]Original Dutch text: "Als ik vier projecten heb liggen wat mooi groen is en eentje zwart, zal iedereen naar die zwarte wijzen."

People's widely varying expectations of green parking also impact how a successful project is viewed. 'Perfect' pictures of previous implementations are often used as a reason not to implement green parking since the expectation is for green parking to be entirely green. If the results do not meet this expectation in their municipality due to various reasons (soil composition, traffic intensity, etc.), green parking is deemed not sufficient and a failure by skeptics. Since there are numerous different opinions on what green parking should be used for and what results should be achieved regarding infiltration, grass growth, and lower temperatures, a consensus cannot easily be reached about the effectiveness of green parking, thus hindering further implementation.

4.1.4. Costs

"*Constructing it [green parking] is one thing, making it function in a future-proof way is just as important.* "[3]— Interviewee 7

Literature often mentions costs as a significant barrier to implementing green parking and other SUDS as mentioned in Section 1.1. Costs were not part of the interview questions but were often brought up by interviewees, suggesting that the topic is regarded as important.

The interviews indicated a lot of internal confusion within municipalities about the overall costs of implementing green parking. This confusion was caused by multiple aspects.

The first one is that each department has its budget and green parking is often not considered a municipality wide project, meaning that each department only focuses on its goals and budget without evaluating the overall financial benefits. Some departments involved might have higher costs when green parking is implemented, for example, the maintenance team for green areas. They have to mow the grass more often and as a result, have higher yearly costs. Other departments, like the sewer departments, might save on costs in the long-term since more infiltration would mean less water drained into the sewer system.

The second aspect is the difference in short versus long-term costs. For example, options for green parking differ in design and maintenance costs. Since every department mainly considers its goals and interests, designers might choose a variant without considering the maintenance costs, like the case with PPs mentioned in Section 4.1.2.

Another factor that plays a role is that there is little literature on long-term maintenance, and maintenance teams work with a limited budget that has been cut in recent years by some municipalities (Interviewee 2). This leads to hesitancy on the side of the maintenance departments.

The last aspect is the balance between costs, expectations, and goals. Often cheaper options lead to expectations not being met and negative experiences.

Multiple interviewees indicated a need for a more comprehensive and detailed cost-benefit analysis for green parking and other SUDS to address these issues.

[3]Original Dutch text: "Het aanleggen is één ding, maar ja, het toekomstbestendig laten functioneren, dat is net zo belangrijk."

4.1.5. Who is Responsible?

The last couple of subsections clarified that multiple departments with various stakeholders are involved in implementing green parking. One of the follow-up questions addressed responsibility. Who was ultimately in charge of choosing whether green parking would be used in a project? And who was responsible for choosing between different products?

Interviewee 8, a project manager, stated that the choice was ultimately his, but the people from the maintenance department were consulted and could provide input for the choice.

Interviewee 9 stated that the maintenance department for public spaces is responsible for implementing green parking since they initiate projects.

Interviewees 5 and 6 mentioned that the decision is a collaboration between the maintenance department, municipal engineering consultancy, and the spatial development team. The involvement of the maintenance department was primarily aimed at preventing new technologies or methods from being implemented without them knowing. They further mention the lack of technical knowledge about maintenance in other departments as a reason for the involvement. Interviewee 7, employed at the same municipality, mentions a different department named Strategy and Programs, which translates policy into specific measures.

Interviewees 5 and 6 also specified the difference between a municipal reconstruction project and a new urban development project. Project developers initiate these new urban developments and the municipality has a supervisory role. They mentioned that they did not have the time and capacity to be fully involved in these types of projects, only joining in at the beginning and end of the project. Interviewee 7 mentioned that there was uncertainty regarding maintenance; the uncertainty revolved around the fact that some people thought the green maintenance team should be responsible, while others argued that it should be the road maintenance team.

Interviewees 1, 2, 3, and 4 work for the same municipality. They all gave different answers when asked about the responsibility for choosing whether green parking would be used. Interviewee 1 placed emphasis on the ambiguity of the responsibility of choice, mentioning the previously touched upon topic of people only thinking within their own department. Interviewee 2 indicated that the project managers were responsible for the choice. He also stated that as long as there is no 'push from above,' meaning policy requiring climate adaptive measures, the implementation will stay dependent on the initiative of motivated individuals. Interviewee 3 stated that the road consultant decided on specific products. Finally, interviewee 4 specified that he consulted on the type of green parking, but it was ultimately up to a designer to choose between different products.

4.1.6. Policy/Strategy

Policies and strategies from higher-ups (politics, management) can influence the implementation of green parking. The interviewees' answers differed significantly in this regard. Not everyone was directly involved with the strategic level of the municipality, so fewer answers were given related to policy.

Interviewee 1 stated that the sewer department was responsible for working on climate adaptation. Interviewee 7 mentioned that his municipality has a requirement for green spaces to be added but not for infiltration to be increased. This requirement aims to improve livability in urban areas and has no relation to climate adaptation. Interviewee 8 mentioned that his municipality has a water storage requirement for project developers, although this does not necessarily have to be stored using green parking or other SUDS.

Interviewee 3 stated that an Alderman pushed him to consider implementing green parking into projects. Lastly, Interviewee 4 mentioned a strategy called *'yes, unless'*. This strategy entails that green parking or other PPSs should be used unless you have a valid reason not to. Other municipalities not part of the interview process, including the Hague and Amsterdam, have similar strategies. It is unclear what reasons fall under 'unless'.

4.1.7. Spatial Design Handbooks

Spatial design handbooks are documents municipalities use to describe the standard methods, materials, and project procedures. They are chiefly aimed at architects, contractors, and project developers. The goal of these handbooks is to maintain uniformity throughout the municipality and to prevent high reconstruction costs. This is done by only allowing 'tried-and-tested' technologies to be used. Not every municipality has a spatial design handbook and the ones that do vary in how extensively they are used and how strict the handbooks are for contractors and other users. They also differ in the specific topics covered in the handbooks and sometimes different standards are used, such as standard pavements or parking space sizes from CROW (a knowledge institute for infrastructure). Usually, the bigger a municipality is, the more detailed and more extensive its handbooks are. There is a wide variety in what municipalities call their handbooks. The most used ones are: Handboek Openbare Ruimte (HOR), Handboek Inrichting Openbare Ruimte (HIOR), and Leidraad Inrichting Openbare Ruimte (LIOR).

Green parking did not appear in any of the handbooks from the interviewees' municipalities, and the pre-interview research yielded no examples of other municipalities that included green parking in their handbooks. Some municipalities explicitly state that green parking and other SUDS—including infiltration crates or other underground solutions—are not allowed. In some cases, green parking was only allowed as reinforcement for road verges. This fully closes the door for any innovative products to be used and is not beneficial to the implementation of innovations. Some municipalities do have pilot programs mentioned in their spatial design handbook, so innovations have to be implemented as a pilot.

Multiple interviewees cited green parking not being a part of the handbook as a reason for their colleagues to be hesitant to implement it. Either because they did not consider green parking a tried-and-tested technology or because they did not have the technical knowledge that would usually be found in a handbook. Various interviewees from multiple municipalities expressed a desire for green parking to be added to the handbook, stating that it would benefit the implementation of green parking.

Adding green parking to the handbook would mean that there is readily available knowledge on the implementation and maintenance, making it easier to widely implement since it would not require an intensive process every time it would be used in a project. However, the way methods or products are added to the handbook and who is responsible for its content is unclear among interviewees and differs per municipality. Even so, they all agree that multiple departments would be involved in this process.

4.1.8. Pilots

"*... we call it a pilot, but it is more like trial and error. It's just trying.* "[4]— Interviewee 2

Almost all interviewees spoke of pilot projects, either ones their municipality executed in the past or ones the municipality is currently involved in. Some were directly involved with the pilots; others knew about them through their colleagues.

Interviewee 4 indicated a need for a more scientific approach to pilots with monitoring and reporting of results. Many projects were named pilots. However, there was no monitoring and no goals were established. It was suggested that these projects were called pilots because of the extra budget available for pilot projects. Other interviewees mentioned that projects were monitored but were unsure of what type and in what capacity they were monitored.

Interviewees 5 and 6 mention the evaluation of a recent project where green parking pavers were used as a road. They also express frustration with the lack of monitoring in other projects. They want to know more about the influence of specific local circumstances on grass growth and infiltration rates and how to maintain the green parking systems properly. They also mentioned that most monitoring is performed on exceptionally poor-performing projects. As residents started complaining, the municipality was forced to review and evaluate the project.

[4]Original Dutch text: "... we noemen dat een pilot, maar het is meer trial and error. Het is gewoon proberen."

Another reason to conduct pilots is that other factors previously mentioned (goals, expectations, handbook) prevent green parking from becoming standard practice, as stated by interviewees. If green parking is to be used in a project, it has to be named a pilot to avoid skeptical colleagues from blocking the implementation.

4.2. Municipalities - Product Information

During the interview process, several questions were asked regarding the choice between different products and what influenced the choice of a specific variant of green parking. This section will address the factors influencing product choice and the way information about the products reaches municipalities.

4.2.1. Factors Influencing Product Choice

All interviewees mentioned specific factors regarding product choice. Some were not specific to green parking but could be applied to concrete pavers or any other pavement as well. These include the strength of the pavers and durability in case of extremely heavy loads. Another requirement for the specific product was that emergency services (fire brigade, ambulance) should be able to drive over the pavers safely.

A widely mentioned factor is the ratio between grass and concrete. If the pavers are designed with more open spaces, more grass will grow, but the paver will not be able to withstand heavy traffic loads. People's specific expertise greatly influenced what they thought the ratio should be. Other factors such as the choice of substrate or grass type were not mentioned as important factors by most interviewees. Only one person mentioned this as a significant factor. It was found that it was harder for a municipality to define criteria the system has to meet than to make a choice between products.

4.2.2. How Does Product Information Reach Municipalities?

Information about green parking products reaches municipalities in multiple ways. The main one is through their own research by looking at company websites and knowledge institutes like RIONED or STOWA. The Green Village was also often named an important knowledge source for exploring the different types of available innovations and for contacting companies for further questions.

Interviewees significantly differed in their contact with companies. Some approached companies to find out more about their products. Others avoided this, expressing skepticism about companies' information about their product. Interviewee 8 named the test results by companies as a significant factor influencing product choice. He also appreciated companies that displayed the development of their products over time.

Interviewees named lack of time as a hinder in the implementation process since they did not have sufficient time to study a variety of products as projects were on a tight schedule and multiple projects were happening simultaneously. Some companies offer a combination of paver, substrate, and grass. This was named as a significant plus by some interviewees as this would relieve them of a significant amount of work when it comes to searching for information.

4.3. Municipalities - External Processes

4.3.1. Other Municipalities

"*Well, to summarize, every municipality is experimenting, or at least doing pilots. And we don't share those results with each other.*"[5]— Interviewee 5

Sharing experiences and results from (pilot) projects between different municipalities is a process that every interviewee determined a positive experience. However, it does not happen as often as they would like. Some interviewees cited that they would encounter colleagues from different municipalities in other settings, conferences for example. Green parking would sometimes be brought up in passing, but interviewees mentioned that contact was rarely sought for that purpose. Other interviewees cited similar experiences; they would meet with other municipalities only when it was related to the water board and would occasionally bring up green parking.

Local circumstances and differences in organization were named barriers to sharing information between municipalities. Differences in size, residents, soil composition, and urbanization were named as reasons why experiences from other municipalities would not translate well into their situation. The organization of municipalities was named as a barrier because every municipality has different protocols for maintenance, so a method that might work in one municipality might fail in another as their strategies are different. It would be hard to change that.

Interviewees 5 and 6 were eager to learn from other municipalities' experiences. They mentioned the lack of a central database where an overview of different projects could be found that would have been carried out in circumstances similar to theirs.

4.3.2. Water Boards

Contact between municipalities and their water board regarding green parking differed depending on the specific water board the municipality fell under. For example, interviewee 9 mentioned that their water board initially had little to no requirements regarding water being stored or infiltrated locally; they were excited about any measures that reduced the amount of water draining into the sewer system.

Other interviewees mentioned that their water board developed a tool requiring municipalities to consider the water balance in new urban developments. Based on the number of impermeable surfaces and the level of urbanization, the tool produced a number of cubic water that needed to be infiltrated or stored and slowly drained inside the project area.

Municipalities would then have to think about ways to store this water and justify their choices to the water board. The water board favors options with no extra maintenance, such as widening or deepening an existing canal or expanding on current green areas. Interviewee 7 stated that his municipality added an additional rule to the water board tool. This rule said that all water that needed to be stored had to be stored in open water, therefore excluding green parking and other SUDS. Furthermore, the storage function of green parking is not recognized by this water board since green parking is, according to them, not guaranteed to store all water during peak precipitation (Hoogheemraadschap van Delfland, 2020). Therefore, green parking can only be used as a semi-permeable area but does not contribute to water storage while using the tool.

[5]Original Dutch text: "Nou ja, samenvattend, binnen alle gemeentes zijn we aan het experimenteren, of tenminste aan het piloten en die resultaten die delen we niet met elkaar."

4.3.3. Residents

The role residents play in the process of implementing green parking often came up during the interviews. Both in how they view green parking and how they influence the way municipalities act.

The goal of green parking is not always clear to municipalities (Section 4.1.1); residents play a role since the grass is a visible part of green parking, while infiltration is a factor that is unclear and seems abstract to a great deal of people. This can influence the way municipalities think about green parking.

Many interviewees had experiences with locals who did not like the idea of green parking. One often cited reason was that it looks messy to them; they expect a tidy street and considered the grass in between pavers undesirable weeds. In addition, inconsistent grass growth was an often-heard complaint as well as trouble with getting out of cars and tripping on the grass.

A lack of knowledge about green parking and not seeing a reason for implementing it were often cited as the main reasons residents were against it. In one extreme case, residents used weed killers to remove the grass since they found it messy. One interviewee cited residents' attitudes towards green parking as a reason for carrying out pilots. This would allow residents to get used to the idea of green parking without any risk.

In the case of new urban developments, new residents' expectations were high since urban plans, including green parking with perfect grass growth, were shown. However, due to dryness and construction vehicles parking for prolonged periods, the green parking spots did not meet expectations leading to numerous complaints. Interviewees mentioned that local politicians were very susceptible to pressure from residents complaining about the implementation of green parking.

4.4. Companies - Products

4.4.1. Product Development

"*It is the total package that ultimately makes it [green parking] work.*"[6] — Interviewee 11

As mentioned before, green parking started as road verge reinforcement. Interviewee 11 stated that his company began looking into implementing it in parking spaces after being asked by a municipality. Initially, results were underwhelming, leading to research into different types of substrates and grass types. Overall, the interest in substrates and grasses has grown and while green parking was initially seen as just different pavers, it is increasingly viewed as a system with three elements that all have to work. However, interviewees stated that not all municipalities had made this shift and when implementing green parking, they only focused on the pavers or slabs. This leads to disappointing results and hesitancy to implement green parking in future projects.

The difference in goals, which was a factor within municipalities, did not play a role on the company side. They all mention that the total package needs to work since good infiltration rates promote grass growth, which results in the growth of grass roots that prevent the soil from clogging. The difference between companies that offer a 'total package' compared to paver producers is significant. Interviewee 10 mentions noticing other companies' websites promoting poor foundations that will not have water storage properties and will not encourage grass growth. This is linked to other factors within municipalities, discussed in previous sections, such as expectations and past experiences since poor advice on foundations leads to negative experiences and a hesitancy to implement green parking again.

[6] Original Dutch text: "... het is het totaalpakket wat het uiteindelijk laat slagen."

Interviewees stressed that local soil circumstances play a significant role in the infiltration rate and the level of grass growth. Interviewee 12 mentioned that soils with a low infiltration rate or high groundwater levels do not necessarily mean that green parking is not suitable, but instead that more attention has to be paid to make the system work, by including extra measures such as drain pipes. Interviewee 10 stated that it is hard to promote their products using a specific infiltration rate because local soil circumstances might yield different results and promoting a high infiltration rate might create unrealistic expectations.

It was mentioned that companies would also like to know more about their own products; since it is a relatively new product, there is not much information regarding long-term factors, specifically. Current development mainly concerns scientifically establishing the infiltration rates, especially in real-life examples of green parking that have been used for several years. They also analyzed maintenance practices and are hoping to optimize those. All interviewees mentioned the fact that the development of products is an ongoing process, taking experiences from previous projects into account when working on new projects.

4.5. Companies - Contact with Municipalities

Companies get in contact with municipalities and promote their products in multiple ways. The Green Village was often named as a way to introduce municipalities to their products. Focusing on the success of previous projects was named as a significant plus. Promoting them on websites such as LinkedIn, usually with an Alderman present, also caused other municipalities to look into green parking. Interviewee 11 mentioned that in previous projects, when more departments were involved in the early stages of the projects, the chances of success were higher. The inter-department collaboration was stated as a significant factor in success.

The fact that water boards sometimes do not recognize green parking as a way to store water (see Section 4.3.2) in their tools was an unknown issue to many interviewees. Interviewee 12 remarked that that meant that companies could not convince potential clients properly of the potential benefits of green parking systems. Costs were also often named as a barrier that companies faced. This does not naturally mean that the prices are higher but rather that they differ from the products municipalities use now. Another difference interviewees noted is the municipality's size and whether or not they had in-house engineering capacity. Interviewee 12 noted Small municipalities often did not have the time and ability to research variants and optimize solutions, so a total package was a significant advantage for them.

Companies often struggle to balance promoting their products and providing municipalities with a realistic picture. One way this was done is by taking pictures of previous projects throughout the year to show how the grass reacts to different types of weather. Another way this was done was by connecting municipalities, partly so municipalities could learn from each other and partly because municipalities often take claims made by companies with a grain of salt. By examining and discussing projects previously carried out by other municipalities, they felt like they were talking to a more objective source.

4.6. Other Results

4.6.1. Patents

For innovative products, patents are often mentioned as a significant barrier to widespread implementation. Patents, especially European ones, are difficult to obtain because they require substantial money and time, which most start-up companies do not have.

In order to obtain a patent, the product needs to be unique. Sometimes, companies run into issues with patented products when they want to use them in the procurement process for government projects. Other companies might claim an unfair advantage and lack a level playing field since they have no access to this patented product, or they only have access to them through a licensing construction via the company owning the patent. This also leads to claims of unfair advantage since the company without the patent has to endure further costs on the same product.

A related issue is procurement law. Section 2.76 of this law states that a government body cannot name a specific product or patent in their procurement process unless it is accompanied by the words 'or equal' (Dutch: 'of gelijkwaardig') (Aanbestedingswet, Section 2.76, 2012). Since one of the requirements of a patent is that the product has to be unique, the product cannot have an equal, thus leading to an unfair advantage and governments not using the product in their projects.

For green parking specifically, patents were not a barrier to implementation. Patents cannot be obtained for products that combine two existing products, e.g. pavers and substrate. This is because different types of pavers are not unique enough—only differing in shape and size—to obtain a patent. However, different methods for producing pavers can obtain patents.

4.6.2. Certification

Product certification is a factor known to be another significant barrier. One of the reasons is the high costs associated with certifying new products. Another reason is the certification itself. A product might be so innovative and unique that it does not fall within current guidelines (Dutch: Beoordelingsrichtlijn) and testing methods. This is solved by formulating new guidelines for the new product. However, this costs time and money, which is especially hard for smaller start-ups to accept. Certification was not found to be a significant barrier to green parking specifically. Some interviewees mentioned that their products were certified. However, this was not related to green parking but to concrete production methods that also applied to other products like pavers or concrete tiles.

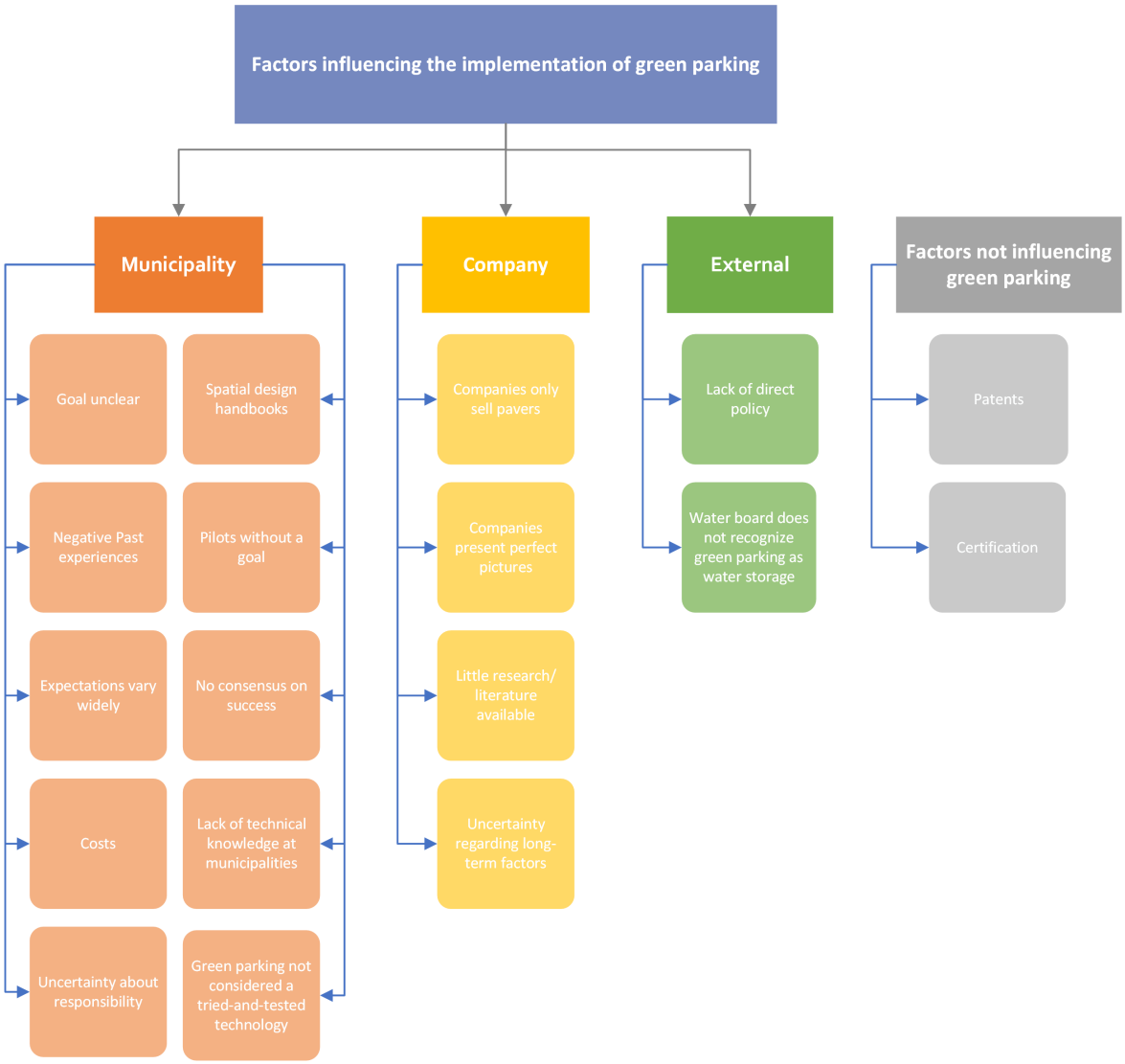

Figure 4.1: Overview of all factors influencing the implementation of green parking

4.7. Analysis

4.7.1. Information Flow 1: Companies and Municipalities

The connections between factors for the information flow between companies and municipalities can be found in Figure 4.2. As discussed in Sections 4.1 and 4.4, green parking is relatively new. This has three implications: uncertainty regarding long-term factors influencing the system, there is little research available on green parking, and it is hard to quantify costs. These three factors lead to varying expectations within municipalities (Section 4.1.3).

Varying expectations also led to negative past experiences with green parking. Negative past experiences were a factor that interviewees often brought up. Three other factors influenced these experiences. These were the fact that certain companies only sell pavers, so information on substrate or grass types is not provided, the fact that companies present perfect pictures of their projects, and the fact that some municipalities do not have sufficient technical knowledge within their organization.

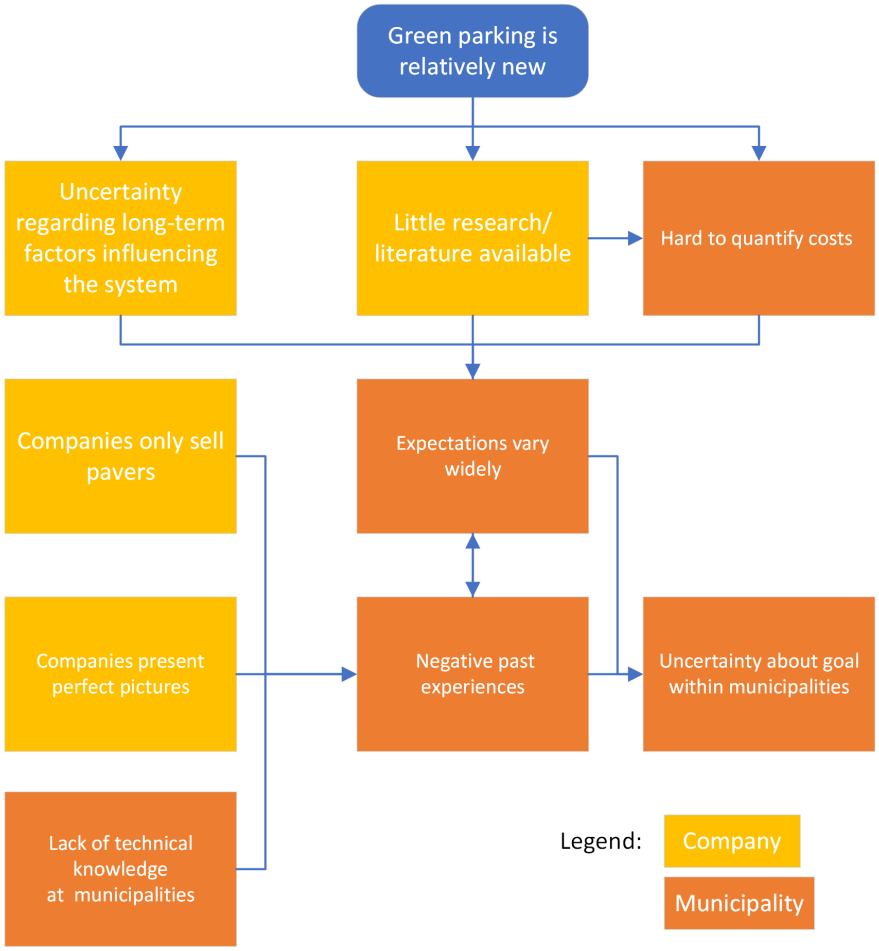

Figure 4.2: Connections between factors discussed in Section 4.7.1

4.7.2. Information Flow 2: Municipalities

Uncertainty about the goal of green parking means that there is no consensus on what a successful project is. None of the interviewees from the municipalities knew of projects involving green parking within their municipality where consensus was reached. It was difficult to reach a consensus regarding multiple factors, such as a main goal or technical performance like infiltration rate and grass growth. Currently, a project could perform well, but since there is no agreement on what a successful project should look like or what technical performance should be reached, skeptics can still call it a one-off and shed a negative light on the project.

This lack of consensus also influences the fact that most people do not consider green parking a tried-and-tested technology, which means that it can not be added to spatial design handbooks.

One aspect interviewees often disagreed on was the responsibility of implementation (Section 4.1.5). When asked who made decisions regarding product types and whether or not to implement them in the first place, answers varied widely, even within municipalities. However, everyone seemed willing to address climate adaptation and ready to use innovative products. Still, there was no clear picture of who was responsible for initiating and leading the process.

The way municipal projects are set up—with the maintenance department as the initiator—leads to an unclear structure regarding responsibility. For example, when a sewer section needs to be replaced, the sewage maintenance department initiates the project, and often the pavement above is also considered for replacement. This is done so that the street is closed only once, saving time and costs, and limiting inconvenience for residents. Their focus is the sewer, so they do not consider it their task to choose green parking. The road maintenance department is usually in charge of maintaining regular, fully paved parking spaces. Still, since there is grass growth, the green maintenance department is also a stakeholder in the process. These two departments might disagree over who the responsible party is and who should pay for it. The costs were mentioned often but are not the main issue; the uncertainty with regard to responsibility means that every department only focuses on its own interests and goals. A more inclusive cost-benefit analysis should be performed to help view the implementation of green parking and other innovations as a municipality-wide project, not a department project.

Another type of project, namely new urban development, only has the municipality as a supervisor. The project developers sometimes have requirements based on water being (temporarily) stored or infiltrated locally. These project developers have no responsibilities regarding maintenance, so they do not take maintenance or how implementing an innovation would impact current maintenance methods into account. There is a difference in short versus long-term thinking between stakeholders. The policy that requires project developers to implement climate adaptive measures should also consider maintenance to prevent unnecessarily high costs for the municipality after development.

All the previously mentioned factors in this section lead to one major issue: pilots without a goal (see Figure 4.3). All municipalities interviewed are currently doing pilot projects with green parking or with another type of SUDS or innovation. No active monitoring examples were found, and neither were examples where results were discussed once the project was completed. According to the literature introduced in Section 2.3, most pilots that were mentioned during the interviews do not meet the standard characteristics and have characteristics that can be categorized as potential failures.

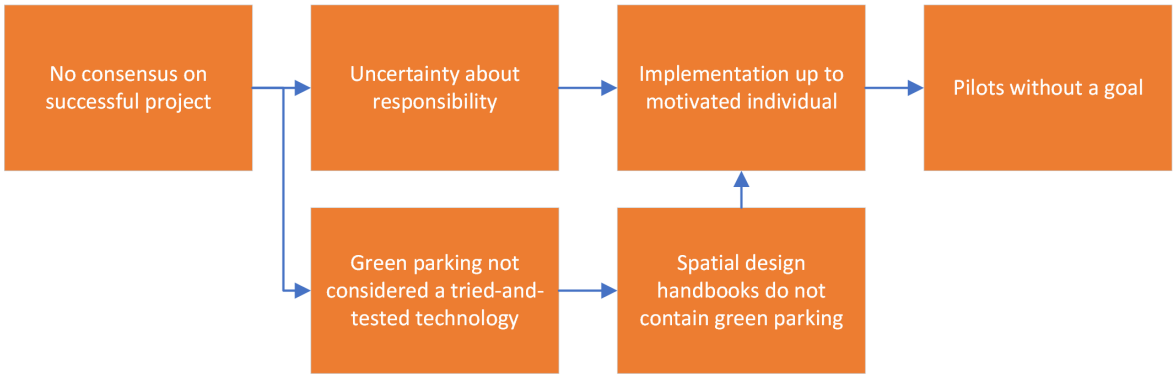

Figure 4.3: Connections between factors discussed in Section 4.7.2

Out of the six listed pilot characteristics (see Table 2.1), four are not met in the pilot projects mentioned in the interviews, namely:

- Falls outside of normal project structure.
- Specific goal or aim.
- Allows for flexibility.
- Clear beginning and end.

The pilot projects mentioned in the interviews did not fall outside the normal project structure but had a similar structure to other municipal projects. There were no specific goals or aims. This stems from other factors mentioned before, where it was discussed that the goal of green parking is unclear. Therefore, the goal of a pilot is also unclear. The lack of a clear beginning and end stems from the fact that there is no consensus on what a successful project will be and the fact that there is uncertainty concerning responsibility. The lack of flexibility can be explained by looking at the variety of expectations within municipalities.

The potential failures were all present, except one: stakeholder involvement. Due to other factors, mainly the lack of consensus on a goal and on how to define a successful project, most potential failures were present in the pilots mentioned in the interviews. Consequently, this results in regular projects masked as pilots, with no lessons learned, no experience gained, and no potential for diffusion or sharing with other municipalities.

Table 4.1 gives an overview of the pilot characteristics and potential failures and compares them to municipal pilots.

Table 4.1: Municipal pilots compared to the standard characteristics and potential failures for pilots, based on Table 2.1

Table 4.2: Pilot characteristics

Pilot Characteristics	Present
Small scale	Yes
Falls outside of normal project structure	No
Specific goal or aim	No
Variety of stakeholders	Yes
Allows for flexibility	No
Clear beginning and end	No

Table 4.3: Potential pilot failures

Potential Pilot Failures	Present
No clear goal	Yes
No consensus on success	Yes
Poor or no monitoring	Yes
Stakeholder involvement too narrow or too broad	No
Lack of follow-up plan	Yes

4.7.3. Information Flow 3: Municipalities and Other Levels of Government

The information flow between municipalities and other levels of government has two factors that influence the process of implementing green parking: climate adaptation strategies and the role of the water boards.

Climate adaptation strategies were introduced in Section 2.5. As mentioned previously, strategies vary in how concrete the plans are, and municipalities struggle with translating policy into concrete projects dealing with climate adaptation.

The climate adaption strategies of the interviewees' municipalities have been considered and analyzed. They all mention the DPSA and the climate-adaptive building covenant. Westland's climate adaptation strategy mentions pilots several times, both in past projects and ongoing ones. However, there is no mention of results or follow-up plans. The goals also remain vague. For example, 'pilots are carried out to create an overview of the consequences of the implementation of the requirements and standards from the climate-adaptive building covenant' (Gemeente Westland, 2021). Again, there is no mention of results from previous pilots or what the goal of these pilots was. Also, there is no mention of who is responsible for the pilots and of a follow-up plan.

Westland's strategy also mentions the specific guidelines regarding climate adaptation specified in the climate-adaptive building covenant. It states that these requirements are the standard 'in principle.' It is also mentioned that for reconstruction projects, these requirements are only a guideline and that the results will be evaluated (Gemeente Westland, 2021). However, there is no mention of what this evaluation will entail.

Westland's strategy also mentions the spatial guidelines handbook. It states that the spatial guidelines handbook will be amended to include climate adaptive measures, but there is no mention of how this will happen and who should do it or is responsible.

Delft's climate adaptation strategy mentions pilots and experimentation in the introduction, but pilots are not mentioned further in the document. There is mention of a monitoring program that measures groundwater levels throughout the city. It is stated that this aims to aid in implementing drainage or infiltration infrastructure as well as green parking or bioswales (Gemeente Delft, 2019). Delft's strategy further mentions a variety of measures that can be used to deal with climate change. These measures are published in a separate catalog. It is not explained who is responsible for these measures and maintenance practices are also not mentioned (Gemeente Delft, 2019).

The aforementioned strategies influence two factors. The first factor influenced is the goal; since the strategies have unclear or vague goals, uncertainty about the goals of green parking will remain since there is no overlapping strategy. The second one is responsibility; the climate adaptation strategies stress the importance of climate adaptation but do not mention who is responsible for implementing specific climate adaptive measures in projects. This is visualized in Figure 4.4.

The influence that water boards have in the implementation of green parking depends on the specific policies of each water board. Most municipalities interviewed fall within the same water board: Het Hoogheemraadschap van Delfland, based in Delft. They are involved in the implementation of green parking with their water tool. Their tool prefers measures without or with little maintenance over green parking or other SUDS or PPSs.

According to the Delfland water board, the storage capacity of green parking cannot be guaranteed during peak precipitation events (Hoogheemraadschap van Delfland, 2020). Therefore, the tool does not allow green parking as a measure for water storage but only considers it a half-paved area. This relates back to expectations and goals. The water board considers 100% of precipitation infiltration as the goal of green parking. Companies play a role here, expanding their target audience to include water boards could convince water boards of their product's effectiveness and performance.

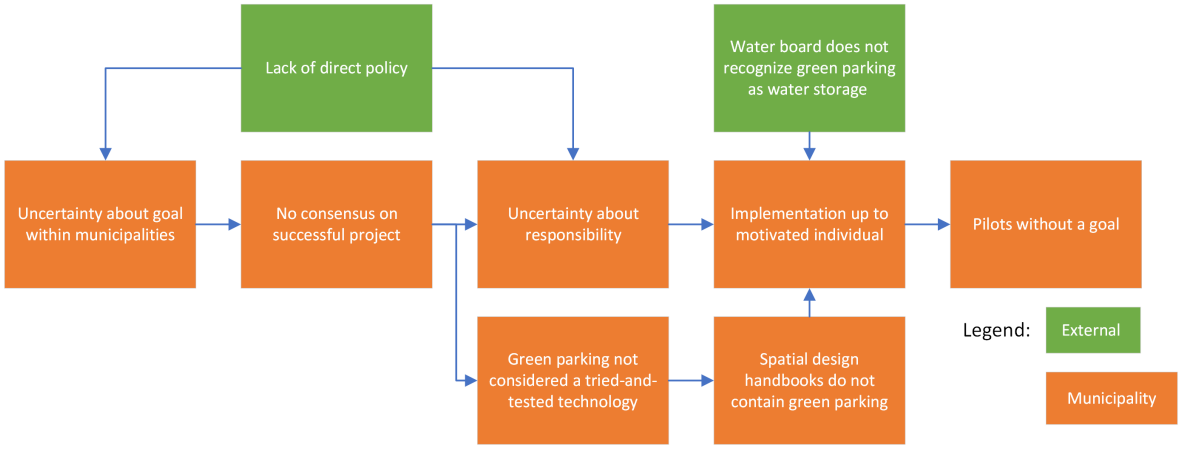

Figure 4.4: Connections between factors discussed in Section 4.7.3

4.8. Conclusion of the Analysis

Considering the results from the previous three sections, three key issues can be identified, which are:

- No consensus on successful project.
- Implementation up to the motivated individual, or agent of change.
- Pilots without a goal.

Out of all discussed issues, these three were the most crucial in the network of related factors. Their connections to other factors are visualized in Figure 4.5, where the key issues are highlighted in red. For the solution phase, these three issues will be closely examined. Out of the three issues, pilots were chosen as the main focus for the solution phase since all other factors lead to the issue of pilots without a goal.

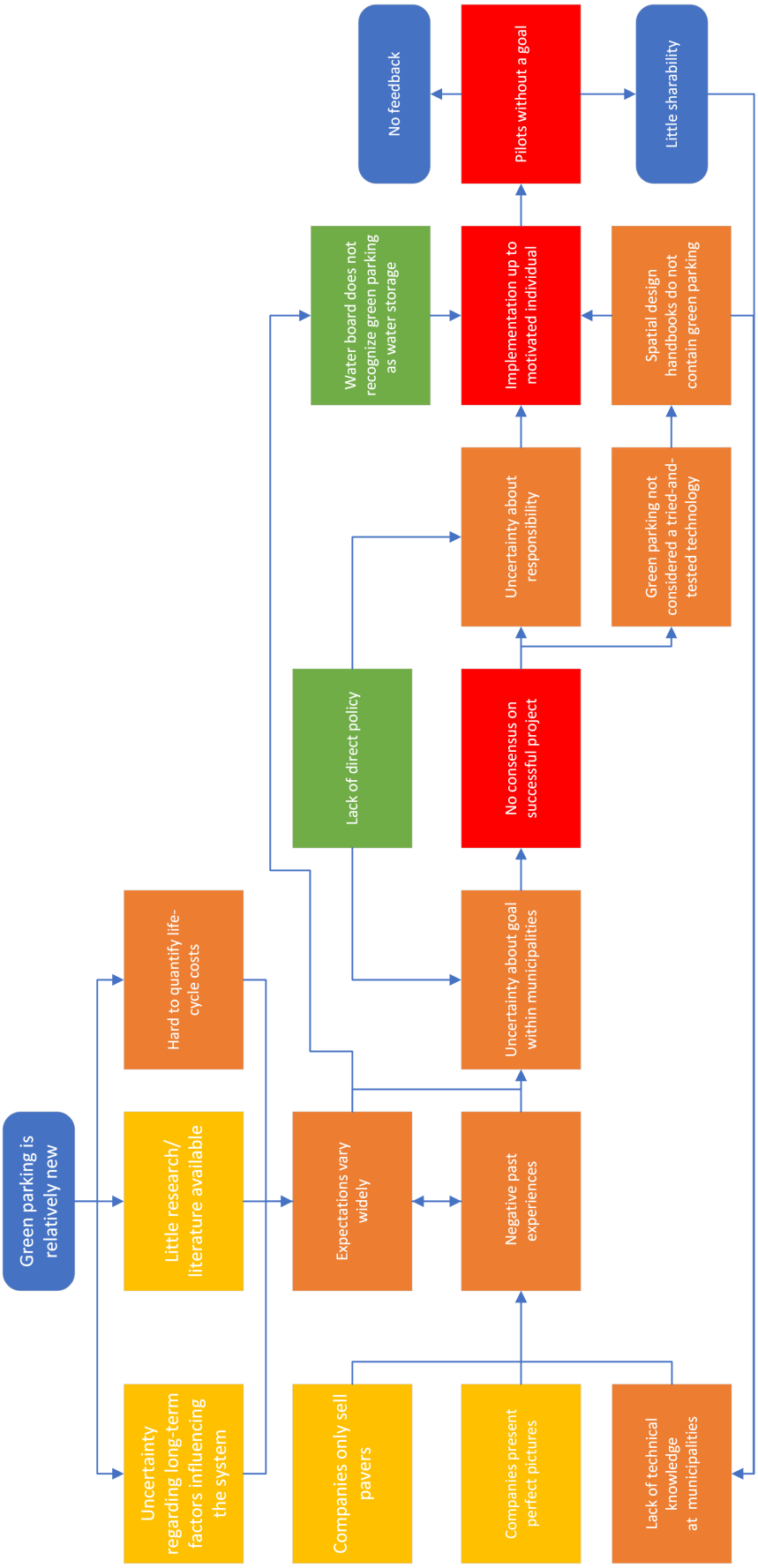

Figure 4.5: Connections between factors found in Sections 4.7.1, 4.7.2, 4.7.3, with the three key issues highlighted in red

5

Results and Analysis: Interviews Solution Phase

This chapter discusses the results from the interviews conducted in the solution phase. These interviews focused on solutions and mainly pilots, especially pilots with all or at least some of the pilot characteristics outlined in Table 2.1.

The interviewees for this phase can be found in Table 3.5. As in Chapter 4, each interviewee is assigned a number which will be used to identify quotes and statements used throughout this chapter. The order of the subsections in this chapter is not used to show significance.

This chapter aims to focus on positive experiences with green parking to ultimately synthesize the experiences into concrete recommendations for municipalities, companies, and other stakeholders.

The chapter's outline is based on the three key issues defined in Section 4.8. First, in Section 5.1, the results related to pilot projects will be considered. Next, in Section 5.2, agents of change will be discussed. After that, consensus on a successful project will be addressed in Section 5.3. Lastly, in Section 5.4, a conclusion is given for both green parking and for other innovations and levels of government.

5.1. Pilots

5.1.1. Amsterdam

"I have noticed that there are at least 15 prejudices about green parking, of which government officials easily name ten and say: so we are not going to do it." [1]— Interviewee 19

During the interviews conducted in the problem phase, pilots were a topic often mentioned by numerous interviewees working at municipalities and companies. However, these pilots did not have the characteristics introduced in Section 2.3 and Table 2.1. For the solution phase, a search for pilots with these characteristics was conducted, aiming to learn from positive experiences with pilot projects.

One pilot project was found, constructed in early 2020 in Amsterdam, and monitored throughout that year (Figure 5.1). The pilot was initiated through a neighborhood initiative. Each city district (Dutch: Stadsdeel) is assigned a 'neighborhood budget,' which residents can use to vote on and initiate projects. Interviewee 19, a resident himself, initiated the green parking pilot. He had asked the municipality to think about implementing green parking but found it hard to convince the local officials, even though they had no specific reason not to test it.

[1]Original Dutch text: "Ik merk dat over het onderwerp groene parkeervakken tenminste 15 vooroordelen bestaan waarvan ambtenaren heel makkelijk er 10 uit de mouw schudden en zeggen: dus we doen het niet."

The pilot consisted of two varieties of green parking on a busy street in Amsterdam; the location was next to a charging station for electric vehicles. This meant that parking intensity was relatively high, but no car would be parked for prolonged periods (longer than the period of time it takes to charge a car). The goal was to prove that green parking was possible in a busy urban street. Some factors were deemed important for the pilot, but not all were measured, primarily due to budget constraints.

Monitoring was done visually by taking pictures throughout the year. No maintenance was done, partly because the maintenance department did not agree with the pilot and partly to see how the grass would grow during different seasons without mowing or extra watering (Stuyver, 2021).

The costs were not representative of a regular project due to the smaller scale of the project; the advice from the pilot report is to make a societal cost-benefit analysis, which takes construction costs into account but also examines other benefits, such as the potential of using smaller sewer systems.

After a year, it was concluded that the project was a success (Stuyver, 2021). This was based on grass growth and infiltration. The grass had grown back from being completely dried out during a heat wave, and during two heavy rain events, the water was infiltrated. The local council for the city district was unanimous in its positive response to the pilot, and possible upscaling was discussed by adding 'green parking, unless' as a strategy for future projects. This never happened, and it is unclear what the reason for that is (Interviewee 19).

Amsterdam's spatial guidelines handbook contains a section on pilots (Gemeente Amsterdam, 2019). It states that if pilots are successful, the product/method can be added to the handbook. However, success is not further defined in the handbook. The handbook also mentions that the committee in charge of the handbook must evaluate every pilot. It does not, however, contain any information about how this evaluation should be conducted or within what time frame it is supposed to happen.

Figure 5.1: Pilot project conducted in Amsterdam (Stuyver, 2021)

5.1.2. Research project Leiden

The pilot in Amsterdam was later used in a more extensive research project that started in 2021 and is still ongoing as of writing this thesis. A previous report considered other PPSs and only lightly discussed green parking. Based on that project, a new Community of Practice (CoP) was initiated, focusing specifically on green parking (Interviewee 20). The municipality of Leiden initiated the project; they wanted to implement green parking but were unsure of the best construction and maintenance methods. Later, other municipalities joined, partly to share the research project costs. Existing green parking projects were used for this project to explore the long-term infiltration rates.

What was going to be monitored during the project was mainly constrained by the available budget. In the end, only infiltration was actively monitored. Other factors were only described, such as maintenance methods or heat stress issues. A great deal regarding proper maintenance practices is still unknown and research is still needed.

It was found that although not all precipitation can be infiltrated, especially during peak rain events, green parking can still be effective. This links back to the variety of expectations different actors might have of the infiltration capacity of green parking. It was also found that high parking intensity is detrimental to grass growth, sometimes even killing it if a car parks on it for a prolonged period of time (Interviewee 20).

5.1.3. Heemskerk

Another case found was the municipality of Heemskerk; for several years, green parking has been the standard and the only way new parking spaces are constructed. The initial push to make green parking the standard method started for two reasons; the first was a shared feeling within the municipality to deal with climate change and to work on mitigation strategies, and the second one was that several people in the municipality were particularly interested in and excited about green parking. There was no specific policy involved that started the process.

Their enthusiasm eventually spread throughout the municipality, including to the maintenance teams. Interviewee 14 mentioned the trust that exists between the maintenance department and the engineering (Dutch: Realisatie) department. Engineers at the municipality convinced the maintenance department to implement green parking by providing them with the right information about the product's benefits and by holding regular meetings to discuss projects. The general consensus within the municipality was that the importance of climate-related benefits outweighed the inconvenience of changing the maintenance plans.

Several years ago, a re-organization occurred, which led to the merging of the maintenance departments and engineering departments. This has been a significant benefit in creating trust and improving cooperation, which helped green parking become the standard in new projects.

Interestingly, pilots have not been a part of standardizing green parking, and there is no spatial guideline handbook. Interviewee 14 stated that testing multiple variants on a small scale was too expensive. Instead, a great deal of freedom is given to designers and engineers to experiment with variations in green parking, mainly focusing on finding optimal substrates and grass species. Through informal meetings, team members keep each other updated on their results, another benefit of merging the two departments.

Expectations also play a role; interviewee 14 mentioned that the municipality changed its expectations from picture-perfect green parking spaces to a more realistic view. This meant accepting a certain risk for projects not to go as well as expected.

The size of the municipality also played a role. Since it is a relatively small municipality, there are fewer people per team, so to convince the maintenance team, for example, not many people need to be convinced. It also makes informal contact easier between team members because they are relatively close to each other since teams consist of mostly the same people across projects.

5.1.4. Pilot Structure

Interviewee 18 mentioned his experience with pilots and the two basic ways to approach a pilot project. One way is to monitor and draw conclusions from the results; another is to set goals beforehand. Following the second way, more accurate results can be obtained that have further use.

The way pilots are structured suggests that there is always a need to compromise. There is a balance between detailed results and costs. The higher the number of factors monitored, the higher the costs. Municipalities usually do not have large budgets to set up intensive monitoring, and it is also not their primary goal to be a research institute. There is also a balance between intensively monitoring one site, comparable to the Green Village, or superficially monitoring multiple sites. One strategy is to start small, involve relevant stakeholders, reach a consensus and not monitor intensively but take pictures instead (like the pilot in Amsterdam).

Another factor that plays a role is the sharing of results. Several sources and websites exist for sharing experiences. The website most often mentioned during the interviews is climatescan, an online platform used to upload pictures, videos, and explanations of previous projects involving green parking and other SUDS (Restemeyer and Boogaard, 2020). Many interviewees (from both phases) stated that they had used the platform to look for comparable projects. The lack of focus on maintenance practices and the inconsistency in the uploaded project descriptions are often mentioned as the downsides. There is a wide variety in detail of uploaded projects. This is a known problem mentioned by the creators (Restemeyer and Boogaard, 2020).

5.2. Agent of Change

The pilot project in Amsterdam, introduced in Section 5.1.1, depended on an agent of change for its initiation. However, even though the results of the pilot were promising and local politicians were excited, the pilot project did not result in wider implementation. This follows the literature introduced in Section 2.4.3, which provides that agents of change are not capable of changing the system by themselves, rather they influence a culture of change (Hughes et al., 2020; Lunenburg, 2010). This was the case in Heemskerk, where the agents of change influenced their colleagues directly, thereby initiating change that led to the standardization of green parking.

5.3. No Consensus on Successful Project

The municipality of Deventer was originally identified as a potential opportunity for interviews because its spatial design handbook contained an appendix concerning PPSs.

This appendix has since been removed from their handbooks. Previous maintenance team members initiated the creation of the appendix without consensus within the municipality. This led to several negative experiences with PPSs and the eventual removal of the systems from the handbook. These negative experiences have led to a change in the use of SUDS; instead of using PPs and a foundation capable of water storage, the road is paved with regular pavers, and water is transported to the foundation through storm drains.

Green parking was used occasionally in Deventer, but there was no consensus on what it should cost and what the goal should be. The design and engineering department focused on short-term costs and performance, while the maintenance department focused on long-term costs. Interviewee 16 mentioned that his solution was to design two standard solutions for green parking. The first one would be cheaper but would not have intense grass growth and might look messy. The second option would be the expensive one that would have better grass growth. In this way, a compromise can be made on the debate of long-term versus short-term costs and what to expect from green parking.

In Heemskerk, a consensus was not reached on the success of each project. Instead, designers and engineers were allowed to experiment on their own. A consensus was reached on an acceptable risk of failure and the lowering of expectations.

The pilot conducted in Amsterdam did not involve all stakeholders, so no consensus was reached with the maintenance department. The lack of an overall consensus might have contributed to the fact that the pilot has not seen any diffusion.

5.4. Conclusions

5.4.1. Green Parking

The interviews for the solution phase uncovered various new insights on implementing green parking. In the case of the pilot performed in Amsterdam, it was initiated and monitored by an agent of change. Linking it back to the MLP, introduced in Section 2.4.1, a niche-level actor introduced an innovation. Still, the regime level did not accept it, and there was no push from the landscape level regarding policy. This hindered the widespread implementation of green parking.

In Heemskerk, green parking became the standard without pilots and without it being added to a spatial design handbook. This confirms that these factors are not necessarily required for green parking to reach widespread implementation. Once again, agents of change were involved in the process.

In Deventer, PPSs were added to a spatial design handbook without reaching a consensus. This generated hesitancy within the maintenance department. Green parking was occasionally used, but there was still an abundance of uncertainty surrounding it. This can be linked to the contested knowledge concept, introduced in Section 2.4.2. As different stakeholders had their own perspectives on what green parking should be, no consensus on success or any other factor can be reached without compromise. This eventually hinders the widespread implementation of green parking.

5.4.2. Other Innovations and Levels of Government

This thesis used green parking as a case study to look at information sharing between municipalities and companies aiming at improving the process of innovation implementation. The interviews focused mostly on green parking, with other innovations being mentioned only occasionally by interviewees in both the problem and the solution phases of the thesis.

However, this does not mean that the results are not applicable to other innovations. Other types of pavements and SUDS will likely face the same barriers as green parking since they are relatively similar in the way they function and the involved departments within municipalities. The spatial design handbooks might be a barrier to numerous innovative products aimed at municipalities as well. Improving the process of introducing innovations to handbooks will benefit not only green parking but other innovations ass well in becoming more widespread.

Other barriers found relevant for green parking and other innovations aimed at municipal projects are the uncertainty about maintenance and difficulty in quantifying life cycle costs. Since the maintenance department is an important stakeholder and is involved in most projects, understanding the best maintenance methods is vital for any innovations to reach widespread implementation.

The three key issues introduced in Section 4.8 are also relevant for other innovations. Multiple municipalities mention pilots in their climate adaptation strategy. Improving the pilot process will benefit all innovations. Consensus on a successful project could also be relevant for other innovations depending on which stakeholders are involved in the projects. The fact that the concept of the agent of change (see Section 2.4.3) is mentioned in different research papers indicates that this issue is not only relevant to green parking and municipalities but might influence projects within governments and companies throughout the world.

Two factors, namely patents and certification (See Section 4.6), did not influence the implementation of green parking. However, multiple interviewees stated that the patent and certification process is a major barrier to other innovations. Certification is especially relevant to innovations that are not comparable to existing products since new guidelines for testing have to be formulated. For patents, the high costs are a major barrier to innovations, especially for smaller start-ups.

Another difference between green parking and other innovations and the barriers they face to wider implementation deal with the scale of the project and the associated costs. Green parking can be implemented on a small scale, therefore keeping costs low. Other innovations might need more space and costs; this might add additional barriers and stakeholder hesitancy.

Furthermore, innovations that are implemented on private property (like green roofs or water retaining innovations in backyards) include the local residents as important stakeholders. During the interviews, the role that residents have in the implementation of green parking was mentioned numerous times, especially regarding their expectations of what parking spaces should look like and how negative complaints might influence local politics. Innovations on private property face more issues related to residents since they have to be convinced of the necessity of installing the innovation and be willing to spend extra money or take time to apply for subsidies (if available).

Innovations are not only used in municipal projects but are also implemented by water boards and by the national government. The water boards also play a role in the implementation of innovations by municipalities. The fact that certain water boards do not consider green parking as water storage was a major barrier to wider implementation; this, however, differs per water board. Water boards also directly deal with innovations; an example of this is the 'Waterinnovatieprijs', a bi-annual contest for innovations in water management. Winners are highlighted on a separate platform called 'Winnovatie', where pilots are discussed as well. A good pilot set-up is, therefore, also relevant for water boards.

On the national level, pilots also play an important role in innovation implementation. The 'Innovatie Testcentrum' plays an important role on the national level in testing new products (Rijkswaterstaat, 2023). Innovations, new types of asphalt for highways, for example, are tested using Technology Readiness Levels (TRLs). Each TRLs has specifications for a pilot project, the length of the asphalt road, and how long the project lasts, for example. Each TRLs also has its own goal, information on what needs to be tested, and what information is hoped to get out of a pilot project. After a positive completion of the pilot project, the innovation can move to the next TRLs. This way of testing new products using pilots is different than the pilot projects mentioned during the interviews, and municipalities could learn from this way of conducting pilots and offering a way for innovations to become tried-and-tested.

6

Discussion

This chapter discusses the results. First, Section 6.1 compares the final results to previous research. After that, in Section 6.2, the research limitations are considered.

6.1. Interpretations of Results

The three key issues established through this research are 'no consensus on a successful project', 'implementation up to the motivated individual or agent of change,' and 'pilots without a goal.' (de Graaf-van Dinther et al., 2021) studied barriers to the implementation of PPSs. Numerous factors found in this research align with the study's findings. The second most important factor found in the study was the 'enthusiasm and perseverance of individuals'. The importance of the agent of change was also acknowledged in (Cettner et al., 2014).

No consensus on what defines a success is indirectly mentioned in the literature, mostly mentioning the factors leading to a lack of consensus (see Figure 4.2). (Biesbroek et al., 2011) cites fragmented knowledge and lack of communication as barriers to climate change adaptation.

Pilots are often mentioned in the literature, although not often in a similar way to how they are mentioned in this thesis. (Deely et al., 2020) cites a lack of knowledge sharing as a barrier for wider implementation of SUDS but does not link this to pilots. A report by 'Programma Nationaal Smart City Living Lab' discusses barriers to widespread implementation of 'smart' innovations (Nouwens, 2018). This report does address issues with pilots in a similar way. The lack of sharing of pilots' results, lack of a pilot goal, and no follow-up plan are mentioned as major barriers to widespread implementation. Since this report discussed different types of innovations, the issues with pilots found in this research might also apply to other innovations.

6.2. Limitations of Research

6.2.1. Interviewee Selection

Although a wide selection of interviewees were interviewed for this thesis, several factors might have influenced the results.

The first one is the selection method. Interviewees were initially contacted through the network of VPDelta+, so each of the municipalities involved have had at least some experience with green parking or have visited the Green Village. This might have excluded municipalities where green parking or other innovations are not being implemented at all or are in the very early stages of implementation. Therefore, this might have led to missing possible barriers to innovation implementation, potentially influencing the results.

This might have led to possible barriers to innovation implementation being missed, therefore influencing the results.

Another factor is the roles of the interviewees and their organizations. For example, most interviewees working at municipalities were project managers or were involved in maintenance. However, during

the problem phase, no one involved in policy was interviewed; this might have led to an underestimation of the role policy plays in implementing green parking and innovations, leading to a bias in the results.

For the solution phase, positive experiences with pilots were sought out in order to learn from them. Unfortunately, not many were found. Maybe there are more positive experiences that are not covered in this thesis, therefore affecting the results.

This thesis involved both companies and municipalities. However, companies were mainly on the supply side. Contractors actually constructing the green parking were not considered. Their experiences might have added valuable insights to the results as well.

6.2.2. Interviews

For the problem phase, the semi-structured interviews, introduced in Section 3.3, aimed at preventing biases built into the questions by allowing interviewees to give their thoughts on any topic outside the set list of questions. The last question of every interview was an open-ended question asking whether the interviewee had anything they wanted to add or felt was missing from the conversation thus far. Even though these measures were taken, a bias in the questions or themes might have influenced the results.

For the solution phase, introduced in Section 3.4, the interviews followed a more structured style based on the key issues. This structure might have introduced a bias in the results.

6.2.3. Recommendations Applicable to Other Innovations

This thesis used green parking as a case study to research the process of innovation implementation and formulate concrete recommendations for both municipalities and companies.

Section 5.4.2 describes the applicability of the results of this thesis on other innovations and levels of government. It was found that the factors influencing implementation are relatively similar for most innovations, especially SUDS since they are similar in the way they function and the stakeholders involved are similar as well.

Other factors might influence other innovations more than they influence the implementation of green parking; these include certification, patents, and the scale and associated costs. Focusing the thesis on green parking might have introduced a bias in the barriers that were uncovered. Selecting other innovations as a case study might lead to more factors hindering the implementation process being discovered.

The three key issues, especially pilots, were found to be relevant to other levels of government as well. The recommendations, which are the main result of this thesis, are therefore also relevant to other innovations and levels of government. For other innovations, the applicability depends on how similar the innovation is to green parking and what other factors are involved that might influence or hinder implementation.

7

Conclusion

Climate change has forced municipalities to rethink urban development. One way to achieve climate-proof urban areas is by implementing innovations. The thesis focused on one specific innovation as a case study: green parking, a relatively new type of permeable pavement system using open pavers, substrate, and a mix of grass seeds to allow precipitation to infiltrate while adding green to urban areas.

Municipalities have slowly started implementing green parking into their projects on a small scale, but numerous barriers still stand in the way of widespread implementation. Many of these barriers are directly or indirectly influenced by how information is shared within municipalities and between municipalities and companies.

This thesis aimed to improve the innovation implementation process by examining information sharing between municipalities and companies, between different departments within the same municipality, and between municipalities and other levels of government. Through interviews with stakeholders from both municipalities and companies, a network of factors related to information sharing was formed (Figure 7.1).

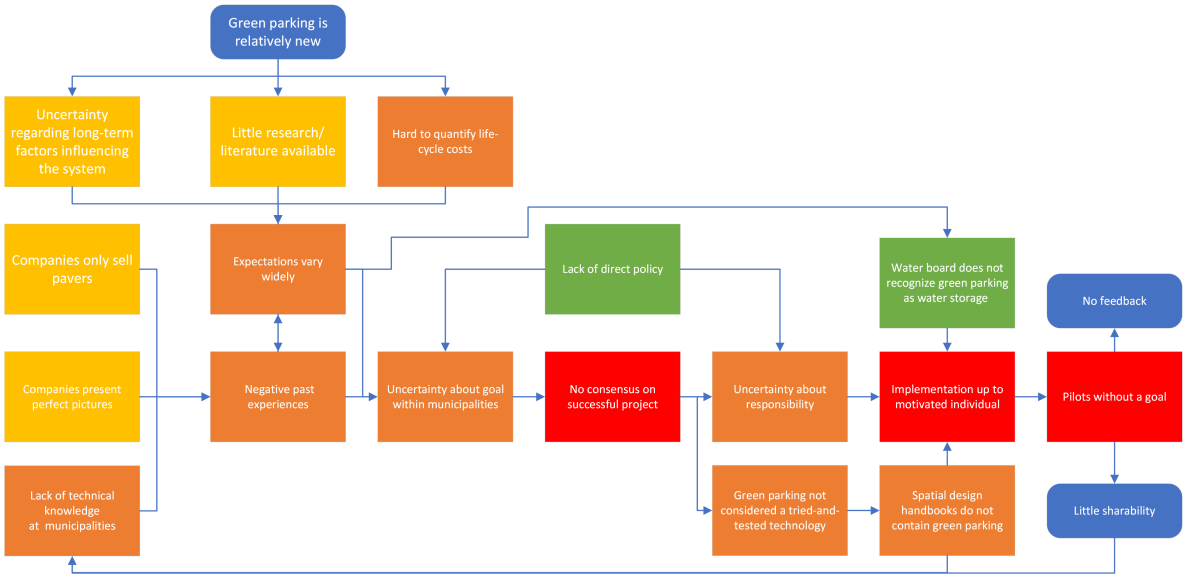

Figure 7.1: Connections between factors found in Sections 4.7.1, 4.7.2, 4.7.3, with the three key issues highlighted in red

An analysis was performed, resulting in the determining of three key issues that hinder the widespread implementation of green parking, which are:

- **No consensus on what defines a successful project:** A combination of negative past experiences, uncertainty about the goal of green parking, and varying expectations within municipalities lead to the fact that no consensus can be reached on what a successful project should look like or what its technical performance should be. Without a consensus on success, skeptics can block further implementation, keeping green parking from reaching widespread implementation.

- **Implementation up to the motivated individual, or agent of change:** Uncertainty about responsibility and the fact that green parking is not featured in a municipal spatial design handbook—since it is not universally considered a tried-and-tested technology—contributes to the fact that if the implementation is to happen, it is up to motivated individuals to overcome barriers and to make implementation a reality.
- **Pilots without a goal:** Pilots were conducted by almost all municipalities interviewed for this research. However, they do not have a goal or aim, have no beginning and end, and produce no shareable or scalable results. Therefore, these pilots are only pilots in name and do not aid in the process of implementing green parking on a wider scale.

The second half of the thesis further researched the three key issues by conducting a second round of interviews. Finally, the results obtained from the interviews were synthesized into several concrete recommendations for municipalities, companies and specific recommendations to improve pilot projects. Chapter 8 outlines these recommendations and specifies which recommendations are applicable to green parking, other innovations, or both.

8

Recommendations

This chapter discusses the recommendations that resulted from the interviews and analyses. First, Section 8.1 lists recommendations for municipalities. Next, in Section 8.2, recommendations for companies are considered, and in Section 8.3, concrete recommendations for pilots are provided. Lastly, Section 8.4 lists recommendations for further research.

8.1. Municipalities

- **Define responsibilities:** Uncertainty about the responsibility of implementing green parking causes the implementation to be dependent on agents of change. Clarifying responsibility will aid in the widespread implementation of innovations.

  For green parking and other SUDS, based on the results from this thesis, the sewer department is the obvious choice to be the responsible stakeholder. This follows from the fact that they are the main beneficiary of the implementation of green parking and other SUDS.

  Another option is to assign responsibility to the official or department head above all other involved departments, which in the case of green parking were the sewer, road, and green departments. Maintenance should also be considered when deciding on responsibility.

  For other innovations, other stakeholders might be involved within the municipality, so defining responsibility will be different depending on the specific innovation. However, clarifying responsibility will improve the implementation process regardless of the specific innovation type.

- **Perform a life cycle cost analysis:** Currently, the cost of green parking is mostly viewed on a department basis, hindering widespread implementation since the departments that benefit from green parking being implemented are not necessarily the ones that have to reserve the extra budget for them. Performing a life cycle cost analysis will provide insights into the overall benefits of green parking. This should also include adding a value to the benefits of green parking, such as increased local infiltration, thereby reducing the amount of water draining to the sewer system.

  For green parking and other SUDS, this should be done using individual projects as the scope to prevent making the calculation too difficult to perform accurately. The project manager or a climate adaptation consultant could perform this calculation.

- **Set concrete and clear goals in climate adaptation strategies:** Pilots are often mentioned in climate adaptation strategies. However, no goal, aim, or timeline is specified. The lack of concrete goals in the climate adaptation strategy hinders the wider implementation of green parking and other innovations.

  To improve this, a separate document related to the climate adaptation strategy and innovation implementation should be created. Depending on the municipality, it will have differences, but some key subjects must be discussed. Firstly these are measurable goals relating to becoming more climate resilient and water robust following the DPSA, a consensus on what climate resilient and water robust means is an important factor in this process. Next, this document should include ways and methods to evaluate and monitor those goals and a pilot program, which will be

discussed separately in Section 8.3. This will benefit both green parking and other innovations related to climate adaptation.

- **Share successful experiences:** Websites like climatescan are used to share project results aiming at knowledge sharing between municipalities. Interviewees noted the inconsistency in detail in uploaded projects and the lack of maintenance strategies. Creating a template for projects will standardize uploads, making comparing multiple projects easier. These templates should include details on maintenance since little information is available on the best maintenance methods and could even include contact details to simplify establishing contact between municipalities. Projects featuring other innovations are also uploaded to climatescan and can also benefit from a standardized template.
- **Spatial design handbooks:** Clarify how innovative products can become tried-and-tested; this can be realized by creating a document with a step-by-step guide outlining what steps companies can take to add their innovation to the spatial design handbook.

  For municipalities, this document can adapt methods from the national government by using TRLs or a variation on this system. This way, a clear road map is established for innovations to become tried-and-tested.

8.2. Companies

- **Create realistic expectations:** Unrealistic expectations have caused significant hesitancy within municipalities to implement green parking. Offering a realistic view by publishing pictures of reference projects throughout the year (different seasons) and projects that have been used for several years will help manage expectations.
- **Water boards:** Out of the company interviewees, only one was aware of the water board's role in municipal projects. Companies could widen their scope and convince water boards of the water storage function of green parking. This could result in the water boards allowing green parking to be used as a water storage measure in their online water tool. This would additionally incentivize municipalities to implement green parking. This recommendations is also usefull for other types of SUDS.
- **Maintenance:** Convincing the maintenance department of the benefits of green parking is crucial for wider implementation. This means more research needs to be performed to optimize maintenance plans to ensure long-term effectiveness.

8.3. Pilots

- **Concensus:** The first step of a pilot should be determining the scope and stakeholders involved. It is key that consensus is reached on the goal, monitoring, and what aspects are measured to determine what a successful pilot would be. Reaching consensus on these elements was found to be essential in Section 2.3.
- **Set realistic goals:** Starting small means fewer risks and lower costs. There should be a balance between scope and stakeholders; a pilot with a smaller scope should involve fewer stakeholders.
- **Diffusion:** Any conducted pilot should have a specific plan for diffusion. This can be upscaling the pilot, replication in another location, or even implementation in regular projects. This should follow the structure introduced in Figure 2.10.
- **Find partners:** Another way of diffusion is to find other municipalities and execute a collaborative pilot project in multiple locations, sharing the costs and risks. This means more results without extra costs. Reaching a consensus on the aspects previously mentioned is vital in this case, since more stakeholders and multiple municipalities would be involved.
- **Balance:** Find a balance between monitoring one location intensively with sensors versus multiple locations superficially by taking pictures on a regular basis.

8.4. Recommendations for Further Research

The thesis' results also allow for further research to take place. A number of suggestions are listed below:

- Further research could widen the scope to include more companies and municipalities. Especially municipalities outside of South Holland or the Randstad.
- A focused study into one municipality could result in other factors or barriers being discovered.
- Further research could focus on innovations with especially high costs or impact on residents. This can potentially uncover new barriers and issues that did not come up in the context of green parking.
- The role of the water boards and how their view on innovations influences implementation could be further researched.
- Further research can set up a pilot program based on the recommendations from Section 8.1. This will result in real-world experience and will improve the process.
- A next step would be to formulate a document outlining the strategy for the implementation of climate adaptation and innovation implementation based on the recommendations from Section 8.1 to gain real-world experience and optimize the process.

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A

Interview Template Municipalities

Beforehand

- Consent form
- Everything can be discussed, the questions are not leading
- After the interview the transcript will be shared, only after permission the results will be used

General

- Wat is your job?
- How does your job involve green parking/innovations?

Internal information

- Which persons and which departments are involved in innovation implementation?
- How does the choice for green parking come about in a project? And who decides?
- In which step of the process is the choice made?
- Who ultimately determines the choice of a particular product?
- Spatial guidelines handbook: Does it contain a section on green parking? Why not? How are sections added?
- Are there examples of projects where the implementation of innovations went well, and perhaps examples of projects where things are/were more difficult?

Product information

- How do you get information about innovative products? (E.g. internet, flyers)
- Which information about innovative products plays a role in the choice during a project?
- What kind of information do you currently have at your disposal about innovative products and in what form?
- Who ultimately determines the choice of a particular product?
- Spatial guidelines handbook: Does it contain a section on green parking? Why not? How are sections added?
- Are there examples of projects where the implementation of innovations went well, and perhaps examples of projects where things are/were more difficult?
- What kind of information about products is missing to make a choice faster? (e.g. information about sustainability, maintenance) and in what form would you like to see this?

External

- Is there contact with companies that offer innovations? If so, how does this communication take place?

- Are you familiar with pilots? e.g. the Green Village)? If so, what role do these pilots play within projects and the implementation of innovations? If not, why not?
- Do you get in contact with other municipalities regarding innovations?

B

Interview Template Companies

Beforehand

- Consent form
- Everything can be discussed, the questions are not leading
- After the interview the transcript will be shared, only after permission the results will be used

General

- Wat is your job?
- How does your job involve green parking/innovations?

Product development

- What types of products does your company sell?
- What specifications are important when testing/developing new products?
- Are products developed with a specific goal in mind? (e.g. infiltration, grass growth)
- How are products tested? And what aspects are tested?
- Are test results published?
- Are there aspects of the product that are still unknown? (e.g. long-term performance)

Contact with municipalities

- How does your company get in contact with municipalities?
- In what form is information available?
- Are municipalities involved in product development?

C

Interview Template Pilots

Beforehand

- Consent form
- Everything can be discussed, the questions are not leading
- After the interview the transcript will be shared, only after permission the results will be used

General

- Wat is your job?
- How does your job involve green parking/innovations?

General

- How was the pilot initiated?
- Who was involved?
- How did you get involved?
- How did relevant stakeholders get involved?
- Was it agreed in advance what a successful pilot would be?
- How was it determined what would be measured and how long it would take?
- Are there things you would have liked to do differntly?
- How did those involved respond to the results?
- Were people who were skeptic beforehand convinced by the pilot?
- Have there been pilots since?